Frontispiece

Several zooids of Plumatella repens at their feeding position. (By courtesy of Dr. G. O. Mackie).

THE UNIVERSITY OF ALBERTA

A FIELD STUDY OF ECTOPROCTA IN CENTRAL ALBERTA

BY

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ABSTRACT

The Ectoprocta are small, aquatic, sessile and colonial coelomates. About 50 species are known to occur in freshwater. This is the first report on their habitats and distribution in central Alberta.

During the study period, from May, 1960 to July, 1962, four species were found. They are:

Fredericella sultana (Blumenbach) 1779
Plumatella repens (Linnaeus) 1758
Plumatella fungosa (Pallas) 1768 and
Cristatella mucedo Cuvier 1798.

Of these species only the occurrence of *F. sultana* in Amethyst Lake was published (Rawson, 1953a).

The present study furnishes the following new information on the occurrence of Ectoprocta in Alberta: *F. sultana* was found in Wabamun Lake; *P. repens* in two sloughs, one near Ellerslie and another near Frank Lake; *P. fungosa* in Amisk Creek, Hastings Lake and Lac Ste. Anne; *C. mucedo* in Amisk Creek, Hastings and Wabamun Lakes; and unidentified plumatellid floatoblasts in Camrose Creek, Lac Ste. Anne, Astotin, Baptiste, Chickakoo, Chip, Cooking, Isle and Wabamun Lakes. These localities, including Amethyst Lake, lie within the confines of 50.5° N. to 55.0° N. latitudes and 112.5° W. to 118.5° W. longitudes at 680 to 1,960 meters above sea

level. These species were chiefly collected on submerged objects at the depth of about one meter in alkaline (pH 7.5 to 9.5) and well oxygenated (86 to 131 percentage saturation at sea level) water.

ACKNOWLEDGMENTS

To Dr. G. O. Mackie, my major advisor, I wish to express grateful thanks for his valuable guidance throughout the entire course of the study. Special thanks are accorded to Drs. V. Lewin and W. G. Evans for reading the manuscript, and also to my friends for supplying me with information on the occurrence of Ectoprocta in the province.

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I. INTRODUCTION

In the fall of 1959, Dr. G. O. Mackie identified several colonies of Plumatella repens in a tank the content of which was collected earlier from a slough near Ellerslie, Alberta. When I approached him for a thesis topic, he suggested this group to me. To test my interest, he advised me to review the available literature in the library and to write a term essay on the subject. In the paper I concentrated on two features that captivated my curiosity then -- the lophophore and the statoblast.

I decided to do a field-study on freshwater Ectoprocta in the Edmonton area.

Since Ectoprocta had not hitherto been investigated in the province, the essential information on their whereabouts and varieties had to be obtained. To limit the study area, a radius of 32 Kilometers (20 miles) from the City of Edmonton was arbitrarily chosen. After the fruitless searches in May and June, 1960, the radius was extended to 80 Kilometers (50 miles). Within this area ectoprocts were found. Their habitats were examined. Later, miscellaneous areas from the central part of the province were also included in the study.

During the study period from May, 1960 to July, 1962, four species belonging to three genera of the Class

Phylactolaemata were collected. The following morphological account of these species is intended to serve as an introduction to the study.

A. A General Account of the Four Species of Ectoprocta Found in Alberta

Hyman (1959) defines the Phylum Ectoprocta as follows:

> "The Ectoprocta are microscopic sessile colonial coelomates that are permanently fastened in exoskeletal cases or gelatinous material of their own secretion, that are provided with a circular or crescentic lophophore and a recurved digestive tract bringing the anus near the mouth, and that lack nephridia and a circulatory system."

Except for two species (Rogick, 1959), freshwater ectoprocts belong to the Class Phylactolaemata, defined by Hyman as follows:

> "The Phylactolaemata are monomorphic fresh-water ectoprocts with a chitinous or gelatinous zoecium, horseshoe-shaped lophophore (tending to be circular in *Fredericella*),

epistome, body-wall musculature, and
open coelomic communications between
zooids."

All members of this Class being closely comparable, classification on a basis of Orders is not customary. Rogick (1935) proposed the following families, which are also accepted by Marcus (1942) and Hyman (1959):

Family Fredericellidae
Family Plumatellidae
Family Lophopodidae
Family Cristatellidae

Among the families, both the Fredericellidae and the Cristatellidae are monogenic, the Plumatellidae have six genera, and the Lophopodidae three. Altogether, there are about 50 freshwater species of which 16 occur in the United States (Hyman, 1959) and six in Canada. Except for the Lophopodidae, all the families are represented in Alberta. The species are *Fredericella sultana*, *Plumatella repens*, *Plumatella fungosa*, and *Cristatella mucedo*. Table I and Figs. 1 to 4 show their morphological characteristics.

The following terms, frequently used in this thesis, are employed in the following connotations:

FLOATOBLAST -- a free statoblast with a well-developed annulus of air cells when mature; without peripheral processes.

LOPHOPHORE -- "a tentaculated extension of the

mesosome that embraces the mouth but not the anus and has a coelomic lumen" (Hyman, 1959). A water current is drawn through the lophophore by ciliary action and food particles are removed by filtration.

POLYPIDE -- the internal, living, movable parts of the zooid.

SESSOBLAST -- a sessile statoblast cemented to the zoecial wall; with or without a reduced annulus of air cells.

SPINOBLAST -- a free statoblast with a well-developed annulus of air cells when mature; with spiny peripheral processes; a type of floatoblast.

STATOBLAST -- an asexual internal bud produced on the funiculus which is a strand of peritoneal tissue traversing the coelom. Statoblasts are produced throughout the growing season following periods of sexual reproduction and are particularly common in autumn. They resist desiccation and freezing and serve for geographical dissemination. Three types can be distinguished: floatoblasts, spinoblasts and sessoblasts.

ZOECIUM -- an exoskeletal case, either chitinous or gelatinous. Some authors extend this term to include the cellular lining of the exoskeleton.

ZOOID -- a complete unit of the colony, that is, the living parts of an individual animal plus the lifeless secreted exoskeleton.

Table I. Morphological characteristics of the four species of Ectoprocta studied, compiled from various sources, chiefly Rogick (1959).

	F. sultana	*P. repens*	*P. fungosa*	*C. mucedo*
1. COLONY				
Form	Plumatellid*	Plumatellid*	Plumatellid*	Lophopodid*
General appearance	Branching antler-like, partly creeping, partly erect	Branching vine-like, adherent in their entire length	Compact masses upon substratum with zoecia fused together vertically	Vermiform, bilaterally symmetrical, with a gelatinous sole and a convex upper surface
2. ZOECIUM				
Boundary	Distinct	Relatively distinct	Not distinct	Not distinct
Color	Translucent tan to brown	Translucent, pale yellow to amber	Translucent, amber to deep brown	Translucent to marble white
Encrustation	Debris, diatoms, algae and sand	Debris, diatoms, algae and sand	Debris, diatoms, algae and sessile ciliates	Nil
Nature	Chitinous	Chitinous	Chitinous	Gelatinous
3. LOPHOPHORE				
Shape	Oval	Horseshoe-shaped	Horseshoe-shaped	Horseshoe-shaped
Rows of tentacles	one	two	two	two
No. of tentacles	17 - 27	40 -60	40 - 60	55 - 99

(cont'd)

* *sensu* Hyman (1959)

Table I (cont'd).

	F. sultana	*P. repens*	*P. fungosa*	*C. mucedo*
4. SESSOBLAST				
Shape	Reniform	Elliptical	Elliptical	Nil
Length (mm.)	0.27 - 0.57	0.42 - 0.51	0.48	
Width (mm.)	0.14 - 0.37	0.28 - 0.38	0.39	
5. FLOATOBLAST				
Shape	Nil	Elliptical	Elliptical	Orbicular with two peripheral rings of hooked spines
Length (mm.)		0.34 - 0.45	0.34 - 0.53	0.75 - 1.25
Width (mm.)		0.22 - 0.29	0.21 - 0.40	0.75 - 1.25
No. of dorsal spines		Nil	Nil	9 - 34
No. of ventral spines		Nil	Nil	20 - 65
No. of statoblasts produced by a zooid	One to two	Several	Several	One

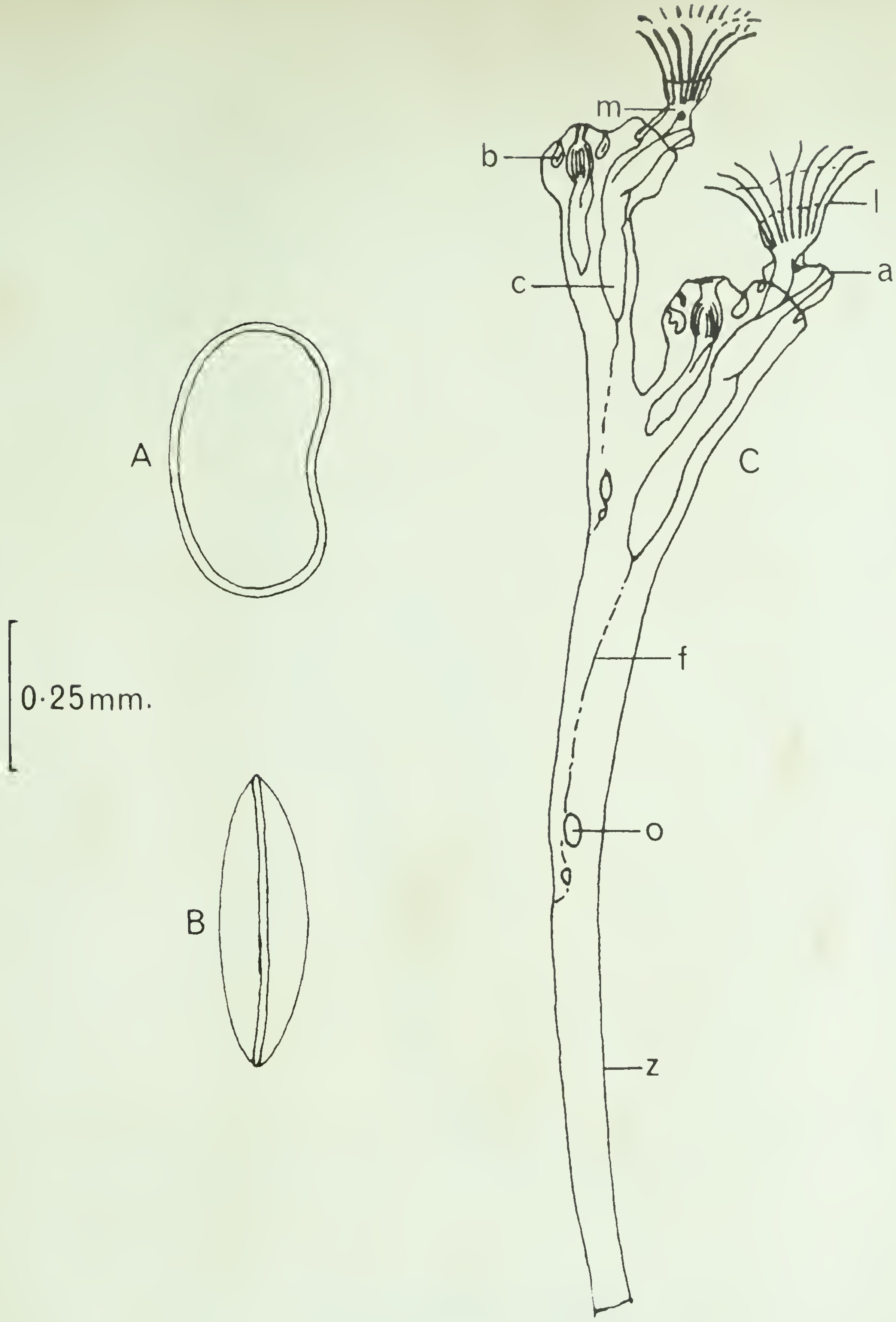


Fig. 1. <u>Fredericella</u> <u>sultana</u>. (A) Sessoblast, front view. (B) Sessoblast, side view. (C) A portion of the mature colony. (After Brien, 1960).

a -- anus	l -- lophophore	r -- retractor
b -- bud	m -- mouth	s -- sole
c -- caecum	o -- statoblast	z -- zoecial wall
f -- funiculus		

As in the following figures, the scales apply to the statoblasts only.

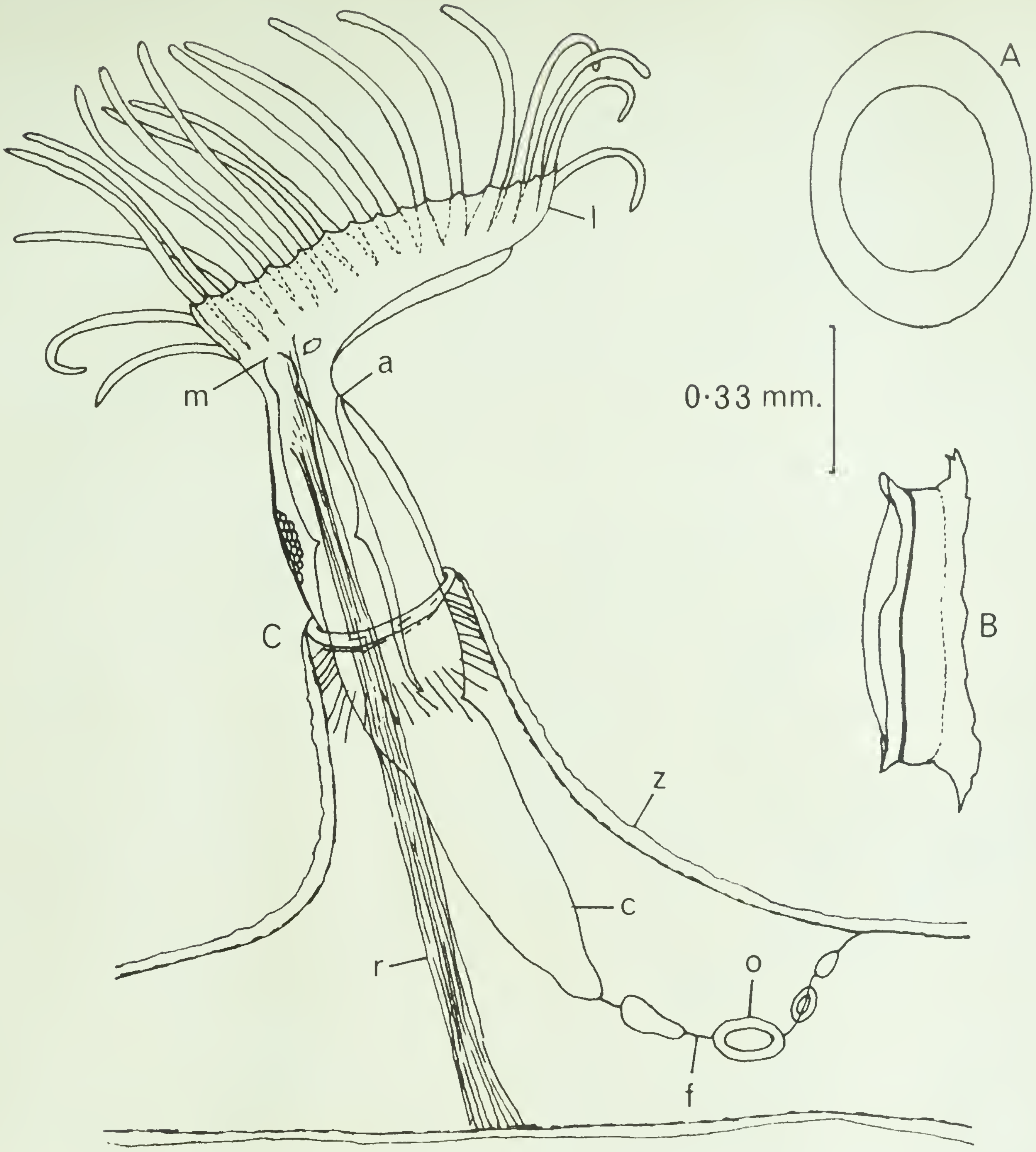


Fig. 2. Plumatella repens. (A) Floatoblast, front view. (B) Sessoblast, side view. (After Rogick, 1959). (C) a mature zooid. (After Pennak, 1953).

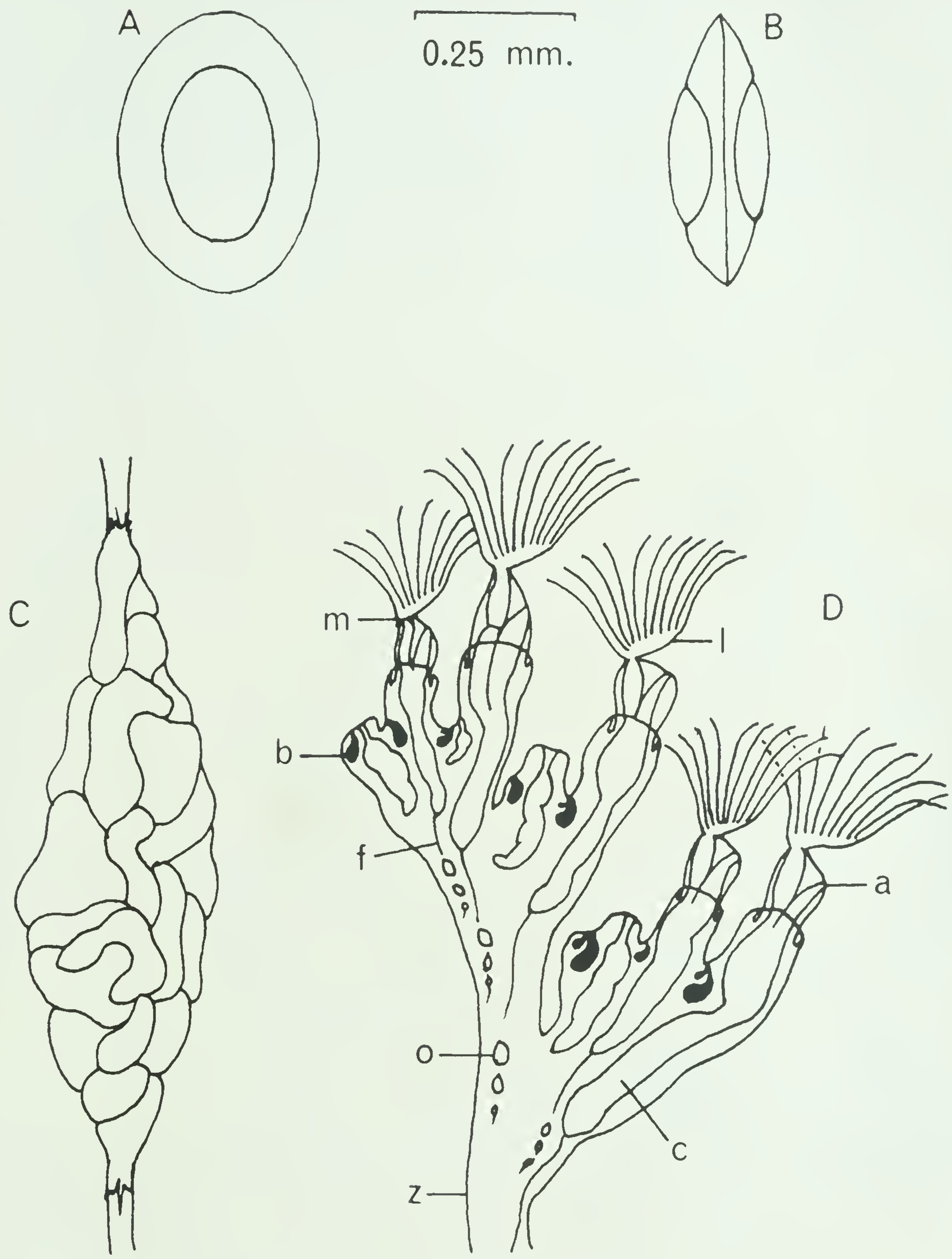


Fig. 3. Plumatella fungosa. (A) Floatoblast, front view. (B) Floatoblast, side view. (C) A colony grown on a twig. (After Allman, 1856). (D) The tip of a mature colony. (After Brien, 1960).

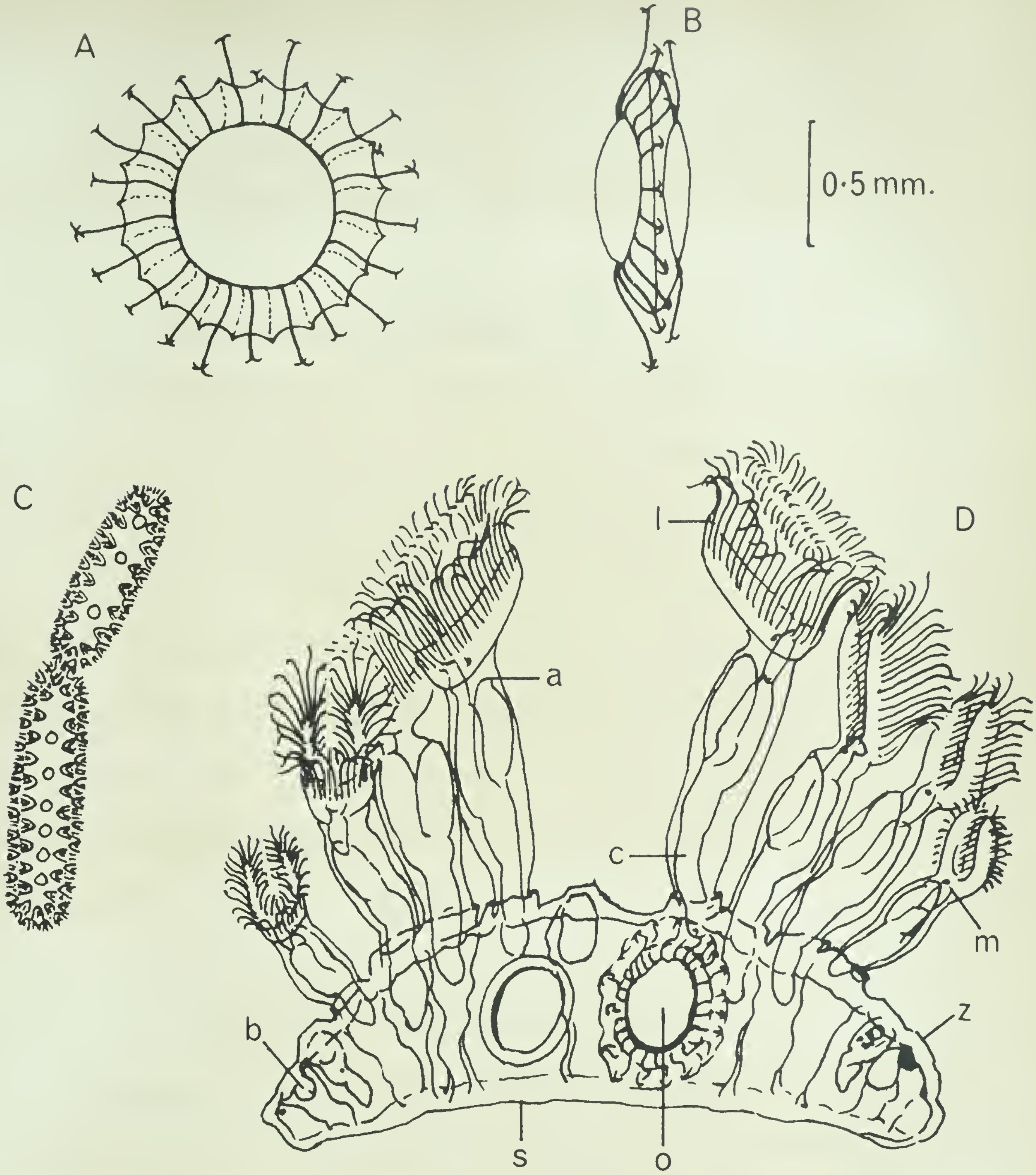


Fig. 4. <u>Cristatella</u> <u>mucedo</u>. (A) Spinoblast, front view. (B) Spinoblast, side view. (After Allman, 1856). (C) Mature colonies after fission. (D) Section across a mature colony. (After Brien, 1960).

B. Previous Records from the Province

Three species of Ectoprocta were known to occur in Alberta prior to this study. (See Table II and Fig. 6).

1. _Fredericella_ _sultana_ (Blumenbach) 1779

This species was collected in 1946 from various depths (down to 21 meters) in Amethyst Lake, a high alpine lake situated at 52° 42' N. latitude and 118° 16' W. longitude at an altitude of 1,960 meters and 24 Kilometers (15 miles) southwest of Jasper in Tonquin Valley by J. R. Nursall, then a student under D. S. Rawson in the University of Saskatchewan. The species, identified by M. Toriumi of Japan, was listed undescribed under "Bottom Fauna" in Rawson's (1953a) paper.

2. _Plumatella_ _repens_ (Linnaeus) 1758

In the fall of 1959, Miss Heather Brown collected some vegetation from a muddy slough eight Kilometers (five miles) east of Ellerslie which is situated at 53° 26' N. latitude and 113° 30' W. longitude at an altitude of 730 meters. From the collection, G. O. Mackie identified several colonies of this form growing on the stems of _Myriophyllum_. (See Frontispiece).

3. _Plumatella_ _fungosa_ (Pallas) 1768

In 1958 R. Carefoot collected a colony of ectoprocts

on a reed stem from Alberta Beach, Lac Ste. Anne which is situated at 53° 40' N. latitude and 114° 21' N. longitude at an altitude of 725 meters and about 73 Kilometers (45 miles) west of Edmonton on Highway 43. In 1960 I identified the specimen as P. fungosa.

II. METHODS

A. Collection of Material

1. Equipment

A pair of rubber chestwaders, a garden rake, and polyethylene pails with lids were used on every collecting trip. The pair of chestwaders permitted free access to the littoral zone within the depth of one meter. The rake was used for collection of submerged objects in the deeper areas.

Other equipment used included a single passenger pneumatic rubber dinghy, a dip net, an Ekman dredge, a glass-bottom viewing box, two larvae traps, wooden crosses and platforms. The last four of these were specially constructed.

To explore the deeper areas the dinghy (Plate IV) was used initially. Being light it drifted readily with the wind and current, and because of its flexible form, reboarding it from water was almost impossible. It was, therefore,

rarely used. Instead, a rowboat was rented whenever possible.

The dip net was invaluable in collecting large colonies grown on submerged stumps. By scraping the stumps with the metal rim of the net, the colonies were detached and retrieved by the net. The net was also useful in collecting floatoblasts.

The Ekman dredge was used on several occasions to survey the lake bottoms for ectoprocts and other fauna.

The viewing box was constructed according to Galtsoff (1959) to facilitate observation and collection of ectoprocts and also to assist reading of the Secchi disk by smoothing the ruffled surface of water. It was a water-proof device with a viewing area of 511 square centimeters. An immersible flashlight was used for illumination but it proved to be of little value. Collections were made, whenever possible, on calm days when the surface disturbance was minimal.

Since larvae tend to settle on submerged objects, glass microscope slides in holders were placed in water. Two of these traps (Fig. 5) were constructed according to Bissonnette (1930). A wooden frame with internal dimensions of 31.5 centimeters by 7.0 centimeters by 2.7 centimeters was made to hold 20 removable slides which are placed horizontally at equally spaced intervals with wires on the open slides to keep them from falling out. The traps were suspended vertically by wire cords at the depth of one meter under the railway trestle in Amisk Creek during the 1961 and 1962 seasons.

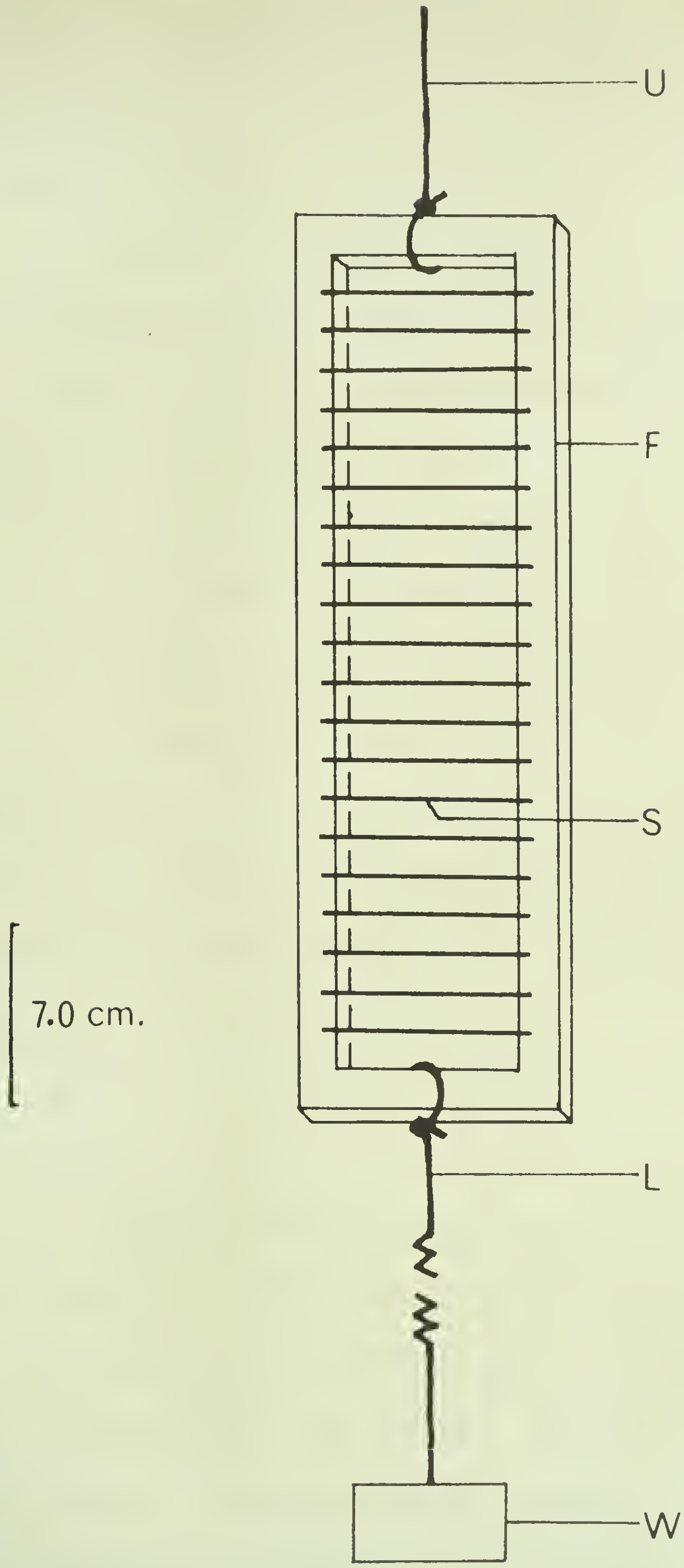


Fig. 5. Larvae trap. The wire cover is not shown.

F -- wooden frame
U -- upper cord
L -- lower cord
W -- weight (at the bottom)
S -- glass slide

The slides were checked from time to time under a binocular dissecting microscope for the settlement of ectoproct larvae and the growth of young colonies.

Wooden crosses, about one meter long, were built according to Grave (1959). It was hoped that larvae would settle and colonies become established on them. Pine and spruce wood was used. Pieces of tile and plastic sheets were attached to some of the crosses for the study of substrata preferences. Set in convenient positions at several points in Amisk Creek in 1960, they were checked from time to time.

Wooden platforms, each with an area of about 0.6 square meter, were also erected at three points at a depth of about 0.5 meter in Amisk Creek in 1960 in an attempt to grow ectoprocts in the natural environment.

2. Collecting Procedure

Four-inches-to-a-mile (1:250,000) topographical maps were used to locate lakes and sloughs in the study area. A locality was chosen for its accessibility. Collection trips were taken frequently but not regularly; usually more than one trip was made every week in summer. As collection was virtually impossible in inclement weather, a trip was made only if the morning foretold a calm and bright day.

Investigations were usually confined to those areas

within the depth of one meter along easily accessible shorelines where wading was possible. Attention was also given to the deeper water if it could be reached by a trestle or a boat. Floatoblasts were first sought among the floating debris which accumulated along the windward side of the shoreline and in the stagnant regions. If floatoblasts were not found, usually no further search was conducted in the area. If their presence was ascertained, the search for mature colonies would ensue. By carefully manipulating the rake, various submerged objects were gathered for examination. Small colonies were collected intact with their substrata but only small portions were taken from large ones. This was done by scraping them off with a spatula or knife if they could be reached by hand, or with the metal rim of the dip net if they were at a distance. Sometimes, collection was done by swimming in deeper areas where the pair of chestwaders was useless and when a boat was not available.

The collection was then gently laid in the water in a pail, covered with a lid, and transported to the laboratory which was usually about an hour's drive away. The colonies were put in aquaria together with water and vegetation from the same area. The tanks were then aerated, covered, and cooled with circulating water in a basin. Wardley's Infusoria Powder was liberally added to the tanks as a diet supplement for the animals. These laboratory cultures were maintained so that systematic studies could be carried out and preservation accomplished under favorable conditions.

B. Survey of the Biotic Environment

From time to time the biotic environment was surveyed qualitatively.

A No. 25 bolting silk plankton net was used to concentrate plankton from a depth of one meter under the railway trestles both in Amisk Creek and in Wabamun Lake. The samples were preserved in 4% formaldehyde.

An Ekman dredge was used to survey the larger bottom fauna in selected areas. The samples were sieved in the conventional manner and the animals were preserved in 4% formaldehyde.

No attempt was made to study the floral communities in detail. However, the genera used as substrata by the ectoprocts were noted.

C. Survey of the Physicochemical Environment

Data on temperature, pH, and oxygen content were recorded on almost every trip. Chemical analyses of water samples, and estimates of limits of visibility and of current velocities were undertaken in some instances.

1. Temperature

Usually a mercury thermometer graduated to 0.2°C. was used to record water temperature near the surface. A reversing thermometer was used on some occasions

for registering temperatures at known depths.

2. pH

In the 1960 season, a ~~Beckman~~ 180 Pocket pH Meter was used to record the pH of the water. Since the apparatus failed to function on several occasions, and since accuracy greater than pH 0.5 was not required, a B.D.H. Universal Indicator that uses a mixture of indicator dyes covering the range of pH from 4.0 to 11.0 was substituted in the subsequent seasons.

3. Dissolved Oxygen

The water taken near the surface was titrated for its content of dissolved oxygen. Occasionally, water taken from a depth by a modified Kemmerer water sampler was tested. Oxygen was determined by the method of Miller (Miller, cited in Taylor, 1949).

To 50 ml. of the water contained in a 100 ml. Nessler glass was added 5 ml. of Solution A (made up of 60 gm. of sodium hydroxide, 173 gm. of Rochelle salt, and 500 ml. of distilled water). A drop of methylene blue was added as an indicator. Then from a 10 ml. graduated pipette, Solution B (made up of 3.1 gm. of ferrous ammonium sulphate, 10 ml. sulphuric acid, and 990 ml. distilled water) was added very carefully just below the surface of the fluid, stirring gently with the pipette all the time, until the color disappeared. The pipette reading gave the amount of dissolved oxygen in milliliters per liter of water. For comparison, the

values were converted to percentage saturation at sea level by taking into consideration the water temperature and altitude according to Rawson (1944).

4. Light Penetration

For the measurement of light penetration in water, a modified Secchi disk, constructed according to Welch (1948), was used. It was lowered into the water by a graduated rope and the depth at which it disappeared was taken as the limit of visibility. The glass-bottom viewing box was sometimes used to facilitate accurate reading. The disk was useful only in Amisk Creek. It was not employed in other study areas where the water was either very shallow or very clear.

5. Current Velocity

To measure the velocity of current, two methods were tried in Amisk Creek in 1961. The first was a wooden block timed after it had drifted for a known distance. The second method made use of a simple, L-shaped Pitot tube constructed according to Welch (1948). These procedures were subsequently discontinued because visual estimation of current flow was deemed to be sufficient for the purpose of the study.

6. Chemical Analyses of Water Samples

Samples of water, one liter each, were sent to the Provincial Analyst whose findings, expressed in parts per million, were listed under the following headings: total

solids, ignition loss, hardness, sulphates, chlorides, alkalinity, nature of alkalinity, nitrites, nitrates, and iron.

Altogether, five analyses were carried out on samples from Amisk Creek, one from Wabamun Lake, one from Hastings Lake, and one from Cooking Lake.

D. Anesthesia, Fixation, and Preservation of Specimens

A representative collection of the species encountered was made. To keep the lophophores fully expanded during preservation, anesthesia was used. Gray's mixture (Gray, 1952), prepared by grinding in a mortar 52 grams of chloral hydrate and 48 grams of menthol, was the favored agent. A small, healthy colony was placed in a clean finger bowl with enough water to bathe the specimen. After the colony had recovered from the disturbance, a few drops of Gray's mixture were sprinkled on the surface. In about 20 minutes, the animals ceased to respond to tactile stimulation, and a fixative was then slowly added. For fixation and preservation, 4% neutralized formaldehyde and Bouin's fluid were used.

Since statoblasts can withstand drying and freezing, they were kept either in the dried form in vials at room temperature or in a refrigerator.

III. RESULTS

A. Distribution of the Species

Altogether, four species belonging to three genera of the Class Phylactolaemata were identified in central Alberta. Plumatella fungosa and Cristatella mucedo were obtained in all the three seasons when the study was made, Fredericella sultana in two, and Plumatella repens in one. In addition, unidentified plumatellid floatoblasts were collected from many localities where the mature colonies were not found. The findings are summarized in Table II and Fig. 6.

B. Environmental Data for Each Species

1. Fredericella sultana (Blumenbach) 1779

Although this species is known from Amethyst Lake (Rawson, 1953a), the lake was not reexamined in this study because of its inaccessibility. Fortunately, an easily accessible habitat, Wabamun Lake, was found in 1961.

a. Wabamun Lake

Wabamun Lake, 19 Kilometers (11.5 miles) long and 6.5 Kilometers (four miles) wide, is about 65 Kilometers (40 miles) west of Edmonton on Highway 16. It is situated at 53° 32' N. latitude and 114° 35' W. longitude at an altitude

Table II. Distribution of the species in central Alberta.

Season	Locality	*F. sultana*	*P. repens*	*P. fungosa*	Plumatellid statoblasts	*C. mucedo*
1946	Lake Amethyst (Rawson, 1953a)	X				
1958	Lac Ste. Anne (coll. by R. Carefoot)			X		
1959	Slough near Ellerslie (coll. by H. Brown)		X			
1960	Amisk Creek			X		X
	Hastings Lake			X		X
	Wabamun Lake				X	
1961	Amisk Creek			X		X
	Hastings Lake			X		X
	Lac Ste. Anne				X	
	Wabamun Lake	X				
	Camrose Creek at Camrose				X	
	Baptiste Lake				X	
	Isle Lake				X	
	Chip Lake				X	

(cont'd)

Table II (cont'd)

Season	Locality	F. sultana	P. repens	P. fungosa	Plumatellid statoblasts	C. muçedo
1961	Lake View, Cooking Lake				X	
	Astotin Lake				X	
1962	Amisk Creek			X		
	Hastings Lake				X	
	Lac Ste. Anne				X	
	Wabamun Lake	X				X
	Slough near Frank Lake		X			
	Chickakoo Lake				X	

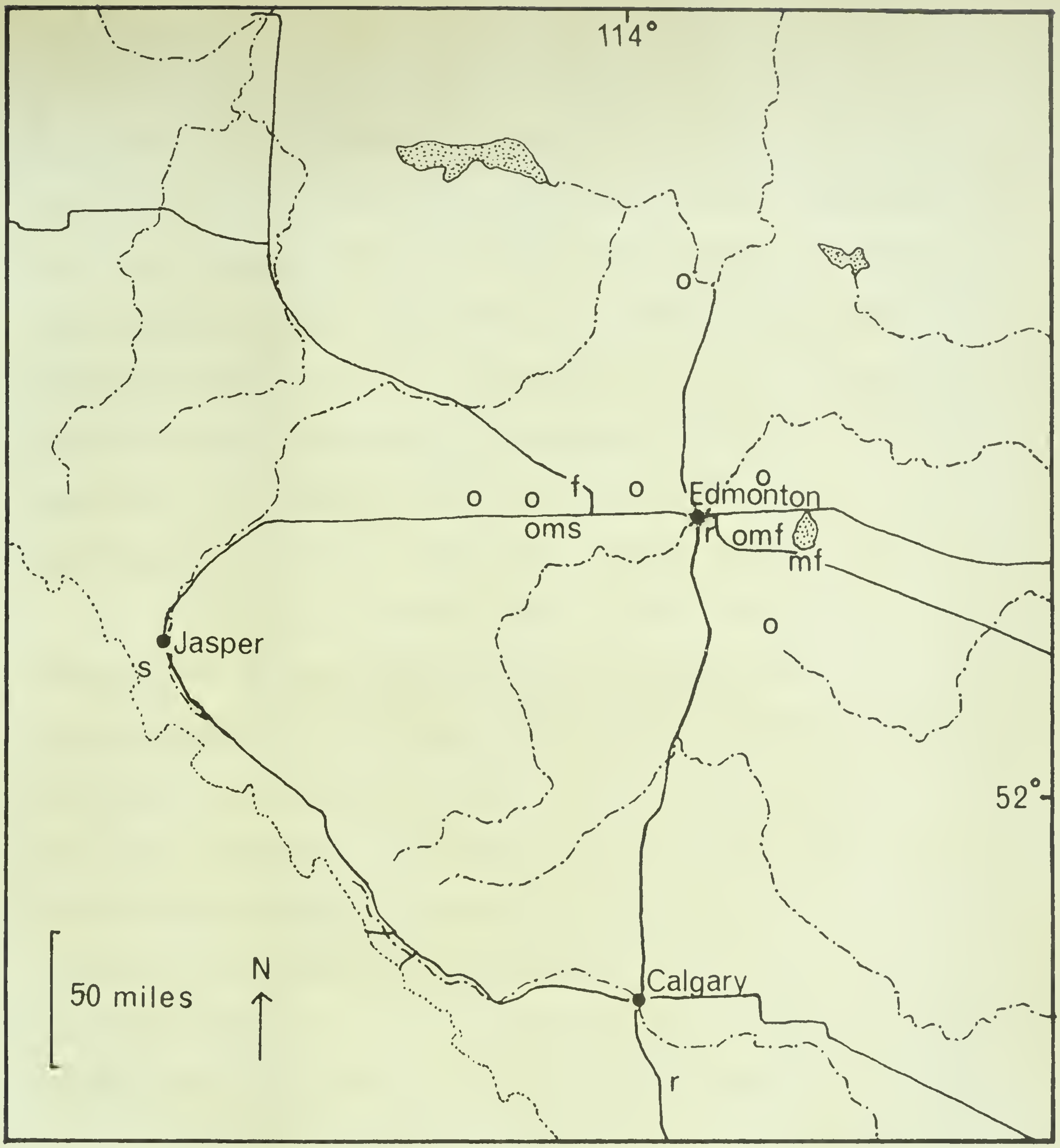


Fig. 6. Central Alberta, showing species distribution.

f -- P. fungosa
m -- C. mucedo
o -- Plumatellid floatoblasts
r -- P. repens
s -- F. sultana

-- Lake
-- River
-- Highway

of 725 meters. There are two railway trestles (Plates I and II) connecting two islets and traversing a sheet of water at the northeastern corner of the lake between Moonlight Bay and the lake proper. It was beneath the southeastern end of the long trestle (Fig. 7 and Plate I) that F. sultana was first found on July 13, 1961, flourishing on the submerged portions of the wooden stumps and functioning pillars, in close proximity with Meyenia sp., a freshwater sponge. The relationship between these two species was not investigated.

Observation under this trestle in 1961 and 1962 showed that F. sultana grew luxuriantly toward the latter part of the season, especially in September and early October when the water was becoming cool. They were still thriving when a thin ice cover was beginning to form at the end of October. No attempt was made to examine their condition after the formation of a complete ice cover. It is probable that the ice would extend to the shallow bottom during the winter months and that the ectoprocts would become frozen in.

On May 31, 1962, colonies of F. sultana growing on the narrow-leaved Potamogeton were also collected from the outlet canal of the Calgary Power Plant, about 1.6 Kilometers (one mile) west of the long trestle (Fig. 7). Having been used as cooling water for the engines in the power plant, the water here was warmer and better oxygenated than the other parts of the lake. The fluctuation of pH was slightly greater, however (Table IV). The canal was open in winter. According to Lewin (personal communication), the water was 20°C. in March, 1962.

Plate I. Southeastern extremity of the long trestle, Wabamun Lake. F. sultana thrived on the submerged portions of the stumps. Note the opening (marked with a white board) for boat passage. September, 1962.

Plate II. The short trestle, Wabamun Lake. No F. sultana grew on the submerged stumps. September, 1962.

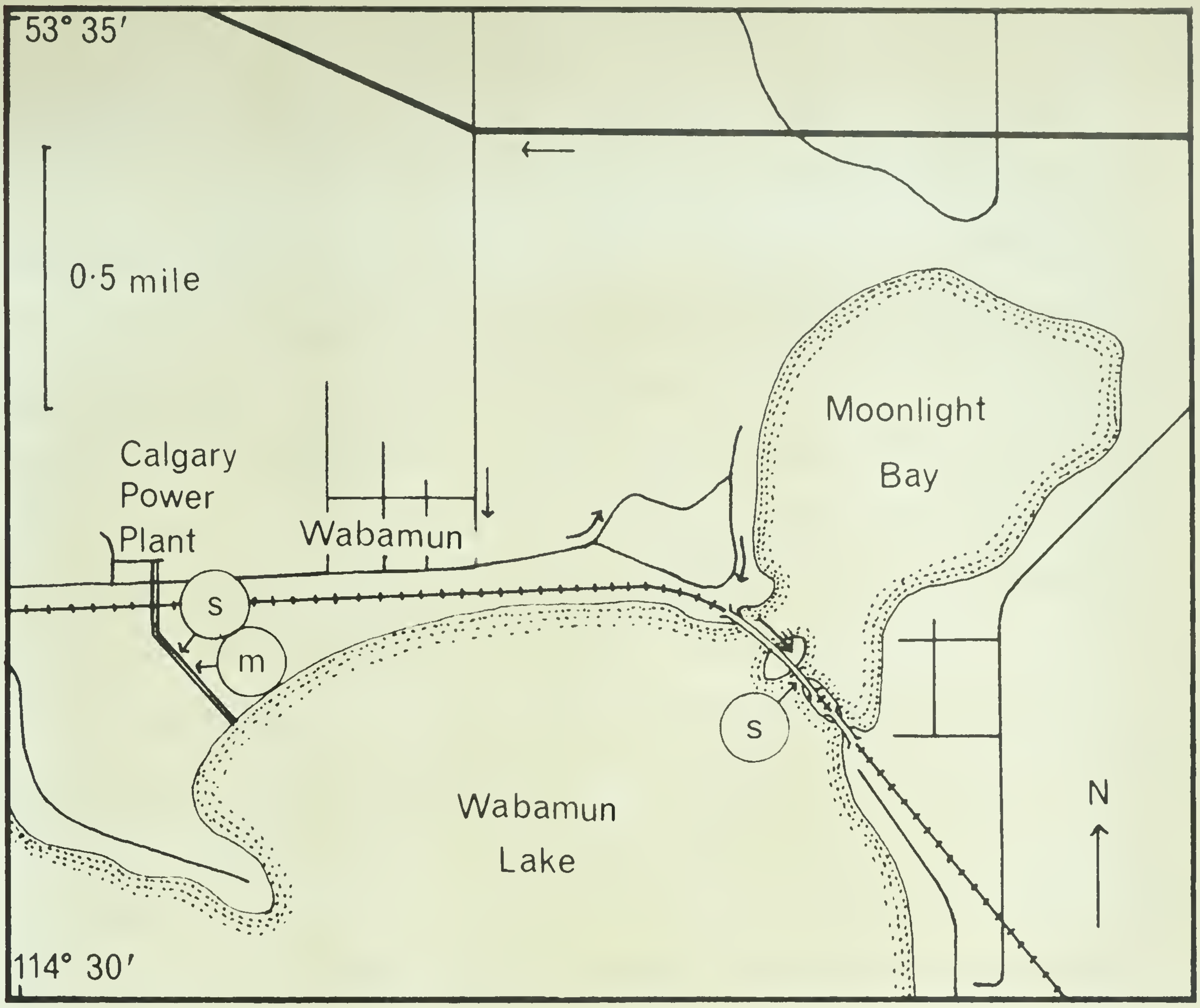


Fig. 7. Distribution of the species in Wabamun Lake.

s -- Region where F. sultana was found

m -- Region where C. mucedo was found

-- Canadian National Railway

-- Gravel Road

-- Highway 16

-- Lake

-- Outlet Canal

-- Route

Cristatella mucedo, too, was collected here in September, 1962.

The forms most frequently collected in the plankton beneath the long trestle were as follows: In October, 1961 there were Anabaena and Oscillatoria (blue-green algae), Actinastrum, Sorastrum and Spirogyra (green algae), Stephanodiscus and Tabellaria (diatoms), Keratella (rotifer), Daphnia (cladoceran) and copepods. In April, 1962 there were numerous Oscillatoria and Phormidium (blue-green algae), Kirchneriella (green alga), Nitzschia (diatom), numerous rotifers and nauplius larvae. In May, 1962 there were Oscillatoria, Ulothrix, numerous Keratella, copepods and nauplius larvae.

Since the bottom under the long trestle was sandy, the Ekman dredge could not be used. Consequently, the nature of the bottom fauna in this habitat was not investigated. There was no vegetation serving as substratum for the ectoprocts beneath the trestle.

The physicochemical data in these two habitats are given in Table III and IV. Table V gives a chemical analysis of a water sample taken from the trestle.

As the depth of water beneath the trestle was not great and as some wave action occurred in the lake, the difference between the water temperature at the surface and at the bottom was almost negligible. On April 28, 1962 the difference was only 0.2°C.

Secchi disk readings were not taken beneath the trestle because the water here was so clear that the bottom was visible. The readings were also omitted in the outlet canal

Table III. Physicochemical data of water beneath the long trestle in Wabamun Lake.

Date	Temperature (°C.)	pH	Dissolved oxygen (% saturation at sea level)
1961			
July 21.	23.0	--	125
Sept. 14.	16.0	8.3	109
1962			
Apr. 28.	6.9	8.0	86
May 15.	12.5	8.5	101
31.	16.0	8.5	109
Aug. 28.	15.0	7.5	102

Table IV. Physicochemical data of water from the outlet canal in Wabamun Lake.

Date	Temperature (°C.)	pH	Dissolved oxygen (% saturation at sea level)
1961			
July 10.	19.5	9.5	--
Oct. 10.	--	--	87
1962			
May 31.	22.0	--	--
Aug. 28.	21.0	7.5	131
Sept. 21.	18.5	7.5	114

Table V. Chemical analysis of water sample taken from the long trestle in Wabamun Lake on April 28, 1962.

	Parts per million
Total solids	194
Ignition loss	12
Hardness	150
Sulphates	23
Chlorides	2
Alkalinity	200
Nature of alkalinity	Na_2HCO_3, $Ca(HCO_3)_2$, and $Mg(HCO_3)_2$
Nitrites	trace
Nitrates	trace
Iron	0.2

where the instrument was difficult to use. Generally speaking, the lake was clear, the quantity of total dissolved solids being small (Table V).

As Wabamun Lake is fairly large, some wave action occurs. The amount of wave action increases considerably beneath the trestle during the frequent passage of small motor boats in the warmer months (Plate I and II). F. sultana, having a considerable amount of chitin in the zoecia (Hyman, 1958), can well withstand this disturbance.

2. Plumatella repens (Linnaeus) 1758

a. Slough near Ellerslie

P. repens was first identified in the fall of 1959 on the stems of Myriophyllum collected from a slough eight Kilometers (five miles) east of Ellerslie. Actually, there are three sloughs in this locality, separated by intersecting gravel roads (Fig. 8 and Plate III). It was the southwestern one that fostered the species. Its shallow, muddy bottom supported a luxuriant growth of vegetation, notably Myriophyllum in the warmer months. The slough, probably dependent on run-off for water supply, did not dry up completely in summer in spite of its small size. Many subsequent attempts have been made here to rediscover the species with no success.

b. Slough near Frank Lake

A slough about 43 meters long lies immediately south

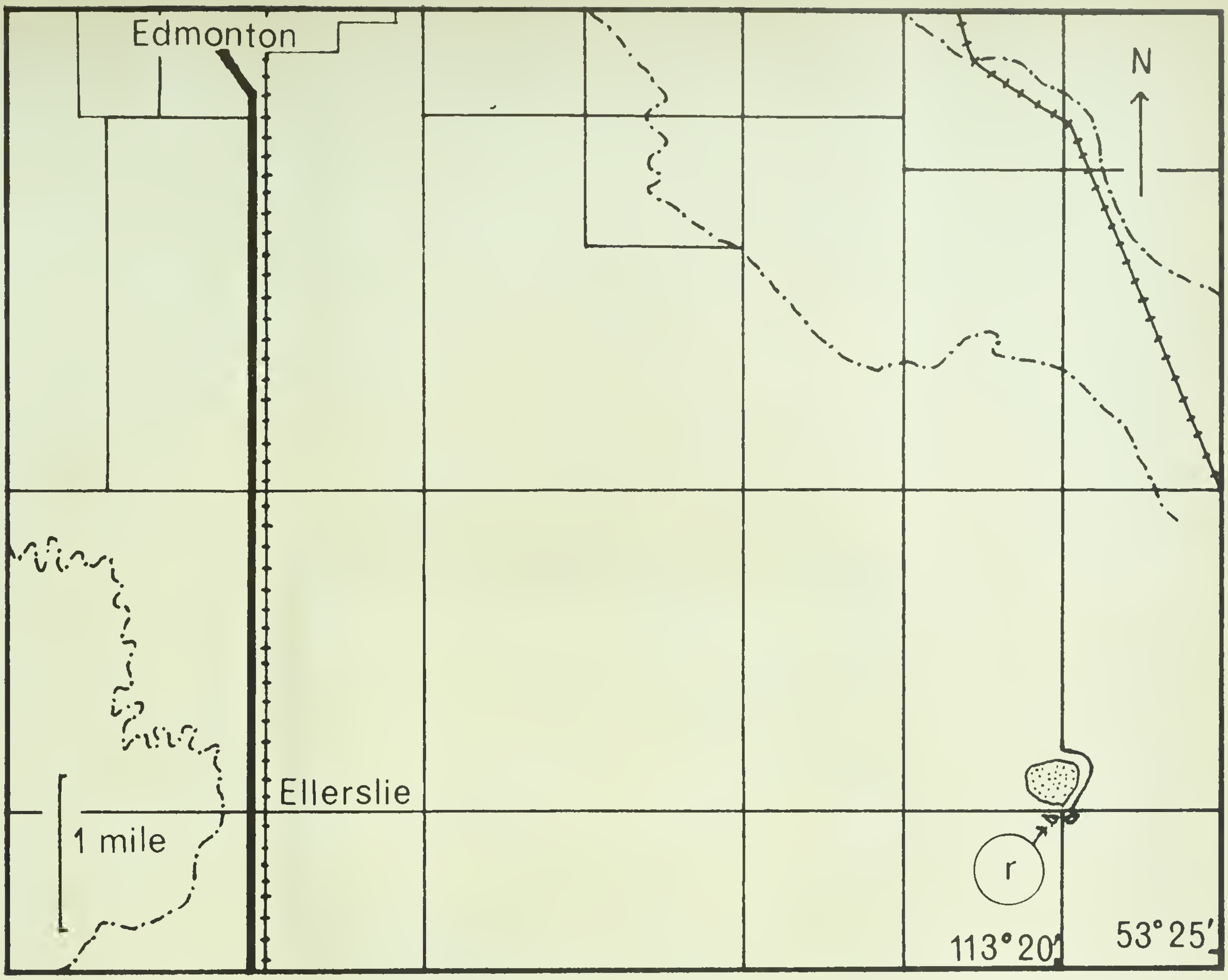
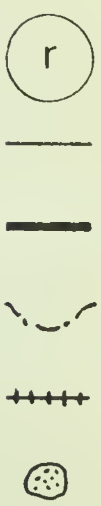


Fig. 8. Slough near Ellerslie.



r -- Region where P. repens was found

—— -- Gravel Road

-- Highway 2

-- Intermittent Stream

-- Railway

-- Slough

Plate III. The group of three sloughs near Ellerslie. October, 1962.

of Highway 23 about 13 Kilometers (eight miles) east of Highway 2 near High River (Fig. 9). When this locality was visited on July 20, 1962, an artesian well with an outlet pipe of 10 centimeters was supplying a considerable volume of clear and cool water (5.5°C.) into the slough, which eventually drains into Frank Lake. The shallow bottom of the slough was composed of soft, black, flocculent mud, rich in decaying vegetation and of repellent odor. Because of its great distance from Edmonton, only one collecting trip was taken. Traceries of healthy colonies of P. repens were collected on reed aggregates at a depth of 0.3 meter near the center of the slough. The water among the reeds was cooler (23.0°C.) and cleaner than the surrounding water (25.5°C.). It was well oxygenated and had a pH of 7.5.

3. Plumatella fungosa (Pallas) 1768

a. Amisk Creek

Fed by four intermittent tributaries, this quiet stream is located at 53° 22' N. latitude and 112° 33' W. longitude and is about 72 Kilometers (45 miles) east of Edmonton along Highway 14 (Fig. 10). It meanders northwards through the farmland area at an altitude of 680 meters into Beaverhill Lake which drains into North Saskatchewan River via the intermittent Beaverhill Creek. Two dams (Fig. 10, Plates IV and V) were built in the lower stretches of the creek to retain water for agricultural purposes, and consequently, the

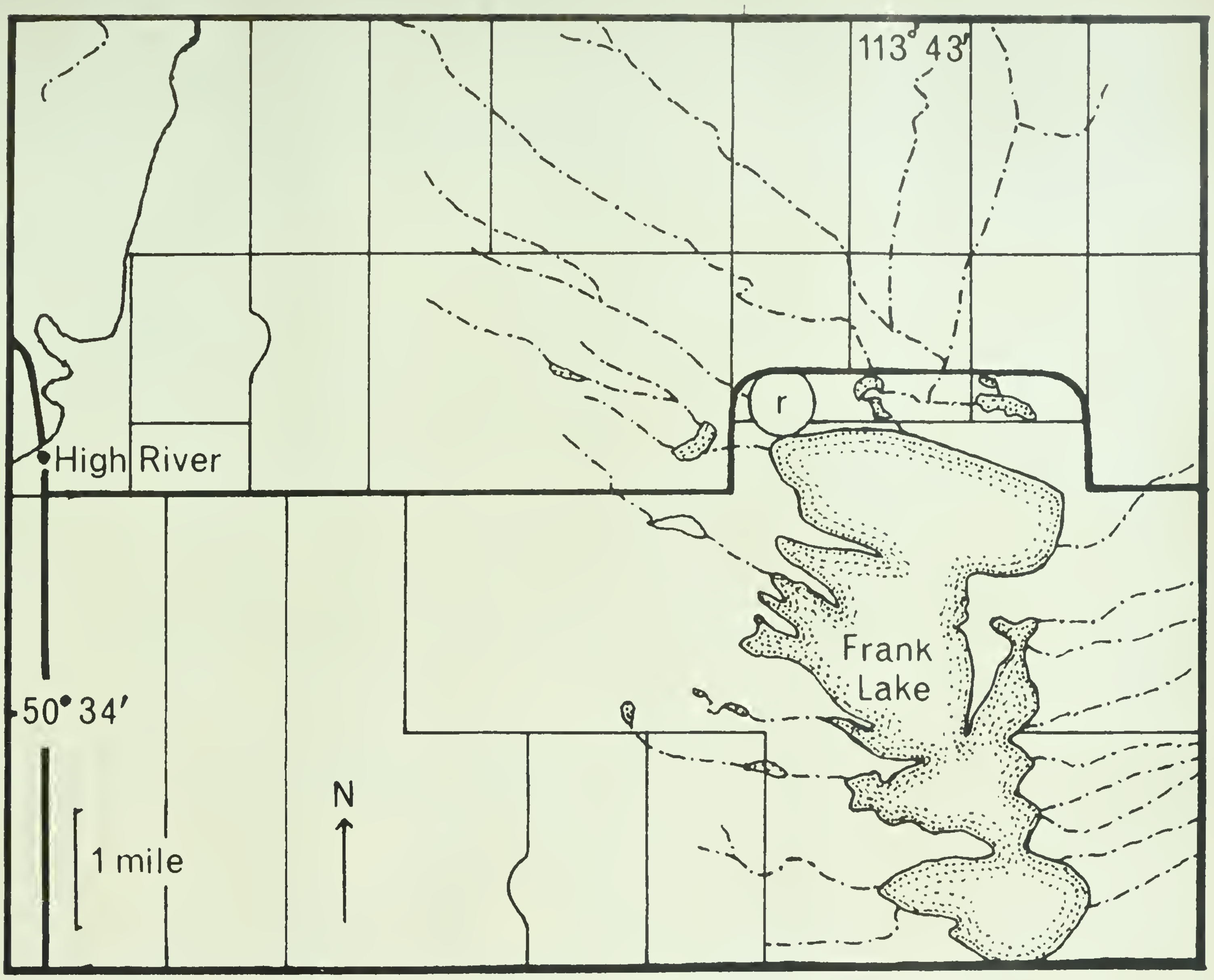


Fig. 9. Slough near Frank Lake (drawn from a 1959 map, the location of Highway 2 has since changed).

r -- Region where P. repens was found

-- Gravel road

-- Highway

-- Intermittent stream

-- River

-- Slough or lake

Fig. 10. Distribution of the species in the lower stretches of Amisk Creek (drawn from an aerial photo).

f Region where P. fungosa was found

m Region where C. mucedo was found

HB Halfway Bridge

KB Kallal bridge

LD Lower dam

PG Picnic ground

RT Railway trestle

UD Upper dam

Highway 14

Gravel road

Canadian National Railway

Bridge

Dam

Intermittent portion of Beaverhill Lake

Elevation: 680 meters

Plate IV. Lower dam, Amisk Creek. The dinghy is shown on the dam. June, 1961.

Plate V. Upper dam, Amisk Creek. September, 1962.

creek was almost stagnant. It is widest in the flood regions created by the dams, being in both cases, about 52 meters wide; it is narrowest immediately below them, being one to two meters across. Two species of ectoprocts were obtained from the lower stretches of this creek.

Colonies of P. fungosa were first collected on June 16, 1960, on a submerged tree branch near Kallal bridge (Fig. 10 and Plate VI). They were later found thriving on many of the submerged stumps beneath the railway trestle near the highway (Figs. 10 and 12, Plates VII to IX). They were also found on the fallen tree branches (Plate IX) and on the stems of the broad-leaved Potamogeton near the trestle. They were dead on October 22, when the water temperature dropped to 6.0°C. Cristatella mucedo, growing near but never in actual contact with P. fungosa beneath the trestle, was more tolerant to low temperature. It was still present when a thin ice cover was beginning to form.

Colonies of P. fungosa were already growing luxuriantly on June 2, in the second season. They continued to flourish until July 31, when their vitality was fatally affected by a sudden drop in the water level of about 0.6 meter. The summer of 1961 was hot and dry (Dominion Public Weather Office, 1963). It was probable that the water was drained for agricultural purposes. A chemical analysis of a water sample taken at that time showed that there was a decrease in the quantities of total solids and sulphates but an increase in the quantity of alkalinity (Table VII). It is

Plate VI. Amisk Creek, north of the Kallal bridge (foreground) where P. fungosa was first collected. June, 1961.

Plate VII. The highway bridge (foreground) and the railway trestle traversing Amisk Creek. September, 1962.

Plate VIII. The railway trestle and the shoreline features of Amisk Creek. Data were frequently taken here. September, 1962.

Plate IX. A close view of the submerged stumps under the trestle in Amisk Creek. A fallen tree which had P. fungosa growing on its submerged portion is also shown. September, 1962.

of interest to note that a phytoplankton bloom occurred at the same time which rendered the usually brownish water green. Although a small colony was found on a glass slide in the larvae trap on August 31, it did not survive for long. C. mucedo, also present in this season, suffered from the same calamity.

In the third season, colonies of P. fungosa were growing luxuriantly again on June 2. They too suffered a calamity on June 14, but this time it was associated with a rise in the water level of about 0.7 meter, abruptly increasing the turbidity, changing the pH from 7.0 to 10.0 and lowering the dissolved oxygen content to 71 percentage saturation. Compared with the 1961 season, the summer of 1962 was cool and wet (Dominion Public Weather Office, 1963). It was probable that heavy precipitation was responsible for the flood. C. mucedo was not found in this season.

Since both P. fungosa and C. mucedo were conveniently found beneath the railway trestle, this site was studied more closely than any other locality in the study. A profile (Fig. 11) shows that the creek beneath the trestle was 28 meters wide and two meters deep and that its muddy bottom did not support vegetation where the water was more than 0.3 meter deep. Of the 47 functioning pillars arranged in eight rows to support the trestle, 37 had some peripheral growth of P. fungosa in 1961. Of the 54 submerged stumps (probably truncated and replaced by the functioning pillars because of their age) nine had some peripheral growth, 15 had some top

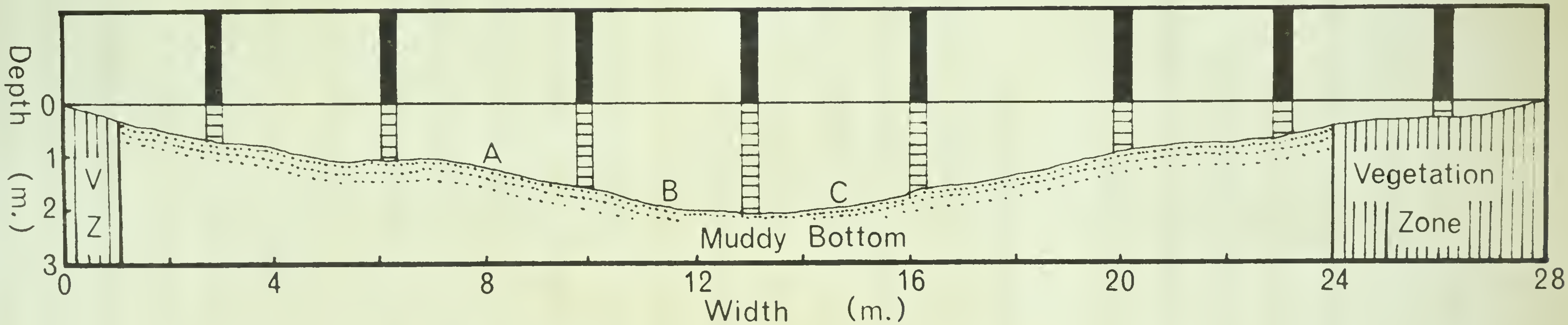


Fig. 11. Profile of Amisk Creek beneath the railway trestle as observed on September 21, 1960. Dredgings were carried out at points A, B and C.

growth, and six had both peripheral and top growth. Only 24 were left unoccupied. It was evident then that two out of three pillars were occupied by P. fungosa (Fig. 12). This species showed a similar growth pattern on the stumps in both 1960 and 1962. It was not true, however, that P. fungosa would grow on submerged wood whenever it was present. The species was not found beneath the wooden Halfway Bridge and the Kallal bridge (Fig. 10).

Ectoproct larvae were not observed on the glass slides of the larvae trap (Fig. 5) at all. In August, 1961, however, several zooids of P. fungosa, together with other sessile objects such as Conochilus (colonial rotifer), snail eggs, and detritus, were found on the slides.

Because the wooden crosses were set in the creek rather late in 1960, ectoprocts did not become established on them in that season. In 1961 P. fungosa grew profusely on one of them under the trestle. The other crosses, including those with pieces of tile and plastic sheets, were left unoccupied. Numerous colonies also grow luxuriantly on the underside of a wooden platform erected beneath the trestle. Like F. sultana on the submerged stumps in Wabamun Lake, P. fungosa also seemed to have a preference for the free flowing water if there is a favorable substratum.

In 1960 and 1962 Spongilla sp., a freshwater sponge, was found growing in close proximity with P. fungosa on some submerged stumps and on some fallen tree branches beneath or near the railway and Kallal bridges. Their relationship was

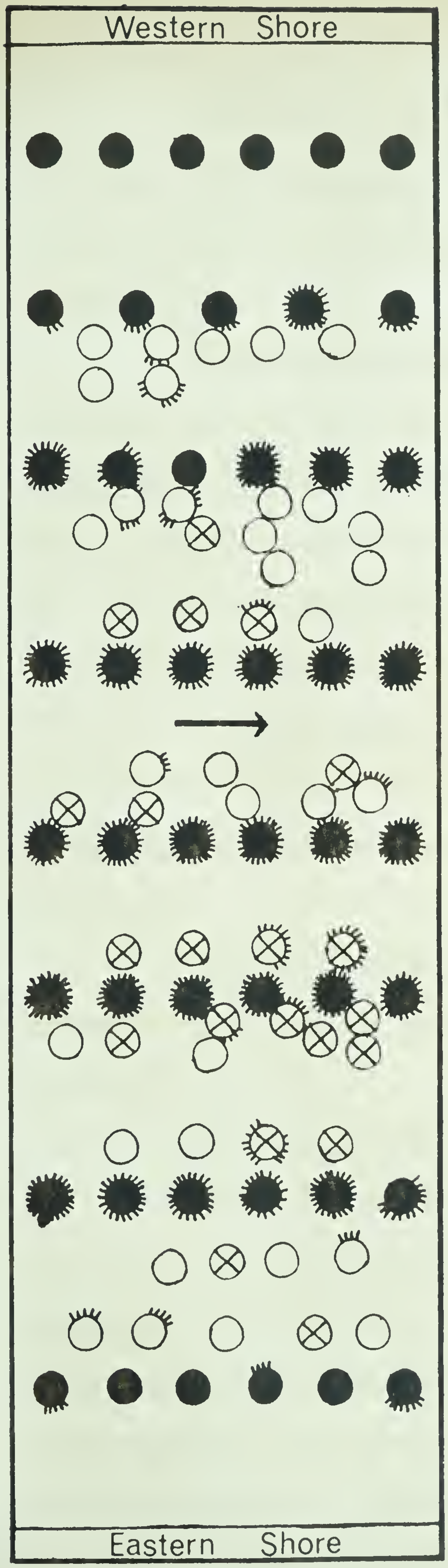


Fig. 12. Schematic top view of the railway trestle on Amisk Creek showing positions of wooden pillars. June, 1961.

Functioning pillar

Functioning pillar with peripheral growth of P. fungosa in the submerged portion

Submerged stump

Submerged stump with peripheral growth of P. fungosa

Submerged stump with top growth of P. fungosa.

Direction of water flow

not investigated.

Numerous animals were found on or inside the massive colonies of _P. fungosa_. The most common ones were chironomid larvae, naid oligochaetes, hydras, sessile rotifers and ciliates.

The plankton most frequently collected beneath the railway trestle were as follows: In June, 1961 there were _Keratella_ (rotifer) and copepods. In April, 1962 there were _Oscillatoria_ (blue-green alga), _Keratella_, and copepods. In May there were _Daphnia_ (cladoceran), copepods, and rotifers. In June there were _Spirogyra_ (green alga), _Tabellaria_ (diatom), _Closterium_ (desmid), numerous _Daphnia_ and copepods. In July there were numerous _Anabaena_, _Coelospharium_, _Phormidium_ (blue-green algae), _Pleurococcus_ (green algae), and copepods.

Compared with Wabamun Lake, Amisk Creek showed a greater abundance of plankton, although fewer species were present.

The major components of the bottom fauna at points A, B, and C (Fig. 11) beneath the trestle were as follows: In June, 1961 there were chironomid larvae (numerous), _Sphaerium_ (bivalves), caddisfly larvae, mayfly larvae, oligochaetes, and leeches at A; _Chaoborus_ (the common phantom midge larvae, numerous), chironomid larvae, oligochaetes, and mayfly larvae at B; and chironomid larvae, oligochaetes, may-fly larvae and bivalves at C. In May, 1962 there were chironomid larvae (numerous), leeches, and caddisfly larvae

at B.

Vegetation grew profusely along the creek. Most notably were the broad-leaved Potamogeton and Ceratophyllum, serving in many instances as substrata for P. fungosa and C. mucedo respectively.

Because the trestle was easily accessible (Plate VIII), most of the field data were taken from here (Tables VI, VII, VIII and IX). Table VI presents the physicochemical data of water taken during the three seasons. Because most of the measurements were taken in the afternoon, the afternoon readings are presented separately in Fig. 13 so that the diurnal influences may be eliminated. The seasonal mean values are also included in the graph. The chemical analyses of water samples are given in Table VII. A gradual decrease in the amount of dissolved chemicals should be noted. Since some ectoprocts were found both in the free flow and in the vegetation zone, a comparison between the physicochemical conditions between these two regions was deemed to be necessary. Table VIII shows that there was indeed some difference between them. The vegetation zones were warmer, more alkaline and much better oxygenated than the free flow. In order to determine if there was any stagnation at the bottom of the creek, the physicochemical conditions of the water collected from the surface and those collected from the bottom were compared. The two comparisons given in Table IX indicate that there was hardly any difference. It should be remembered that vegetation was lacking at the bottom (Fig. 11). In three

Table VI. Physicochemical data of water from the railway trestle at Amisk Creek.

Date	Temperature (°C.)	pH	Dissolved oxygen (% sat'n at ~~sea level~~	Limit of Visibility (m.)	Time taken
1960					
June 16.	19.0	--	116	--	E
17.	21.0	--	111	--	E
Aug. 3.	21.0	8.5	127	1.2	A
4.	21.0	8.0	86	1.2	M
11.	25.0	--	121	1.2	A
19.	19.5	9.3	100	1.2	E
20.	17.5	--	84	--	D
20.	17.5	--	51	1.0	M
Sept. 3.	16.5	8.5	113	1.0	E
4.	14.5	8.5	80	1.0	M
4.	18.0	9.0	113	0.8	E
10.	16.5	9.0	113	1.0	A
11.	16.5	8.5	106	1.0	A
14.	18.0	9.0	113	1.0	A
21.	13.0	8.5	109	0.7	A
22.	10.5	8.0	96	0.7	A
27.	10.0	8.0	109	0.7	A
Oct. 7.	11.0	8.0	95	0.7	A
8.	8.0	8.0	90	0.7	A
16.	7.5	8.5	103	0.8	A
22.	6.0	8.0	99	0.9	A
29.	3.5	7.5	85	0.9	A
Nov. 6.	3.5	7.5	85	1.0	A

(cont'd)

Table VI (cont'd)

Date	Temperature (°C.)	pH	Dissolved oxygen (% sat'n at sea level)	Limit of Visibility (m.)	Time taken
1961					
Apr. 30.	12.0	7.5	91	1.1	A
May 17.	14.0	7.6	91	1.2	M
26.	19.0	8.1	76	1.2	A
June 2.	24.0	7.9	113	1.2	A
9.	24.0	7.7	110	1.2	A
20.	23.5	8.0	109	1.1	A
29.	24.0	8.8	118	1.0	A
July 4.	24.0	8.7	148	--	A
14.	26.0	8.5	150	0.6	A
Aug. 31.	18.0	8.2	89	--	A
Sept. 4.	18.5	8.7	140	--	A
12.	12.5	8.5	129	--	A
16.	15.0	9.0	120	--	A
24.	10.0	8.8	109	--	A
Oct. 7.	8.0	8.7	90	--	A
10.	7.0	8.5	88	--	A
1962					
Apr. 29.	8.0	8.0	90	1.3	A
May 10.	13.5	8.0	96	1.2	A
21.	18.5	7.0	86	1.0	A
June 2.	18.5	7.0	89	1.6	A
17.	23.0	10.0	71	0.6	A

A -- Afternoon E -- Evening

D -- Dawn M -- Morning

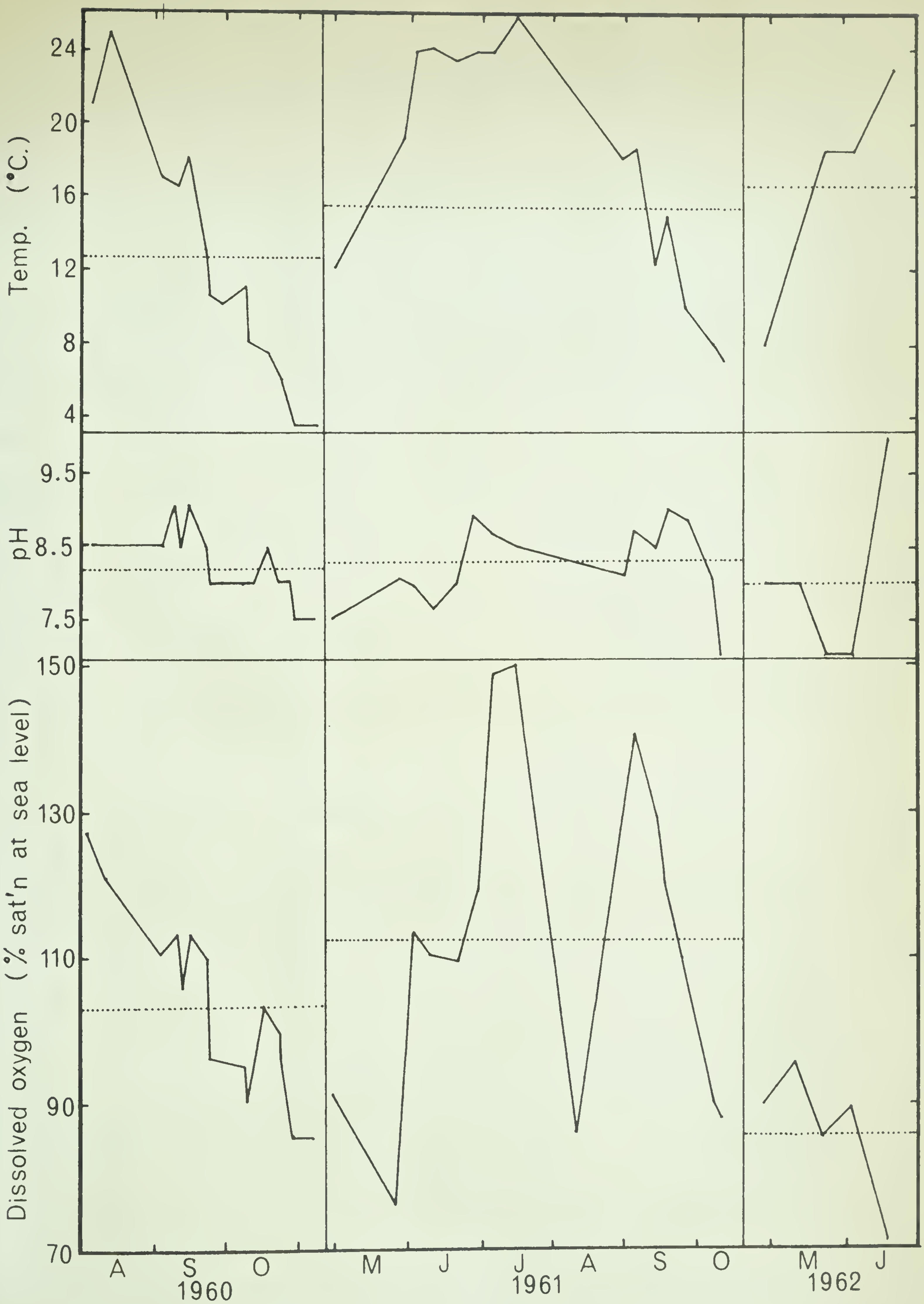


Fig. 13. Physicochemical data of water from Amisk Creek, taken from Table VI, are afternoon readings only. Dotted lines indicate mean values.

Table VII. Chemical analyses of water samples from Amisk Creek.

Date	1960		1961		1962	Average
	Sept. 9.	Oct. 22.	May 26.	July 14.	Apr. 20.	
Total solids	400 p.p.m.	412 p.p.m.	324 p.p.m.	284 p.p.m.	234 p.p.m.	331 ppm.
Ignition loss	130	92	98	98	32	90
Hardness	105	100	80	80	105	94
Sulphates	106	87	84	39	82	80
Chlorides	8	2	7	5	0	4
Alkalinity	195	200	110	140	100	149
Nature of alkalinity	Na_2HCO_3 $Ca(HCO_3)_2$ $Mg(HCO_3)_2$	Na_2HCO_3 $Ca(HCO_3)_2$ $Mg(HCO_3)_2$	-- $Ca(HCO_3)_2$ $Mg(HCO_3)_2$	Na_2HCO_3 $Ca(HCO_3)_2$ $Mg(HCO_3)_2$	-- $Ca(HCO_3)_2$ $Mg(HCO_3)_2$	-- -- --
Nitrites	trace	trace	--	--	--	--
Nitrates	trace	trace	--	--	--	--
Iron	1	2	2	--	--	1

Table VIII. Comparison of the physicochemical characteristics of water collected from the free flow and from the vegetation zone beneath the railway trestle at Amisk Creek in 1960.

Date	Source	Temperature (°C.)	pH	Dissolved oxygen (% sat'n at sea level)
Sept.10	Free flow	16.5	9.0	116
	Vegetation zone	21.0	10.5	oversat'd
11.	Free flow	16.5	8.5	106
	Vegetation zone	21.0	10.5	oversat'd
14.	Free flow	18.0	9.0	113
	Vegetation zone	21.0	10.0	oversat'd

Table IX. Comparison of the physicochemical characteristics of Amisk Creek water collected from the surface and the bottom beneath the railway trestle.

Date	Source	Temperature (°C.)	pH	Dissolved oxygen (% sat'n at sea level)
Oct. 23, 1960.	Surface	6.0	8.0	96
	Bottom (2 m.)	5.0	7.5	91
Apr. 29, 1962.	Surface	7.8	8.0	90
	Bottom (2 m.)	7.0	--	--

instances the physicochemical conditions at various points along the creek was measured in consecutive days (Table X).

b. Hastings Lake

Hastings Lake, eight Kilometers (five miles) long and two and a half Kilometers (one and a half miles) wide, is situated at 53° 25' N. latitude and 112° 55' W. longitude at an altitude of 740 meters and is about 50 Kilometers (30 miles) east of Edmonton on Highway 14 (Fig. 14). On its northern shore, an unnamed, intermittent stream flows in from Cooking Lake. On its eastern shore, a small, intermittent stream, Hastings Creek, connects Beaverhill Lake, which eventually drains into North Saskatchewan River via Beaverhill Creek. It fostered Plumatella fungosa and Cristatella mucedo in 1960 and 1961 but only the former in 1962. Floatoblasts of P. fungosa were first collected on August 10, 1961 on Weslake Beach, a resort area. On September 4, the beach was subjected to considerable disturbances, due to dredging and application of copper sulphate by the owner of the estate. Numerous colonies of P. fungosa growing on the stems of the broad-leaved Potamogeton were dredged from the lake bottom and left lying dead on the beach. Although live colonies of this species were not collected from this area, their presence was confirmed. On October 7, live colonies growing on reed stems

Table X. The physicochemical changes of water in three sets of two consecutive days at various points along Amisk Creek in 1960.

Date	Location	Temp. (°C.)	pH	Dissolved oxygen (% sat'n at sea level)	Visibility (m.)	Time taken
Aug. 3.	Railway trestle	21.1	8.5	127	1.2	A
4.	Railway trestle	21.0	8.0	86	1.2	M
Aug. 19.	Old house	20.0	9.1	111	--	E
19.	Railway trestle	19.5	9.3	100	1.2	E
19.	Kallal bridge	19.0	--	99	1.3	E
19.	Halfway Bridge	19.0	--	123	1.2	E
19.	Picnic ground	18.0	--	113	--	N
20.	Picnic ground	15.0	--	70	--	D
20.	Railway trestle	17.5	--	84	1.0	D
20.	Railway trestle	17.5	--	51	1.0	M
20.	Old house	19.5	--	150	--	M
20.	Lower dam	18.0	--	85	--	M
Sept. 3.	Railway trestle	16.5	8.5	113	1.0	E
4.	Railway trestle	14.5	8.5	80	1.0	M
4.	Railway trestle	17.0	8.5	111	1.0	A
4.	Railway trestle	18.0	9.0	113	0.8	E

A -- Afternoon

D -- Dawn

E -- Evening

M -- Morning

N -- Night

(Material deleted after submission of thesis)

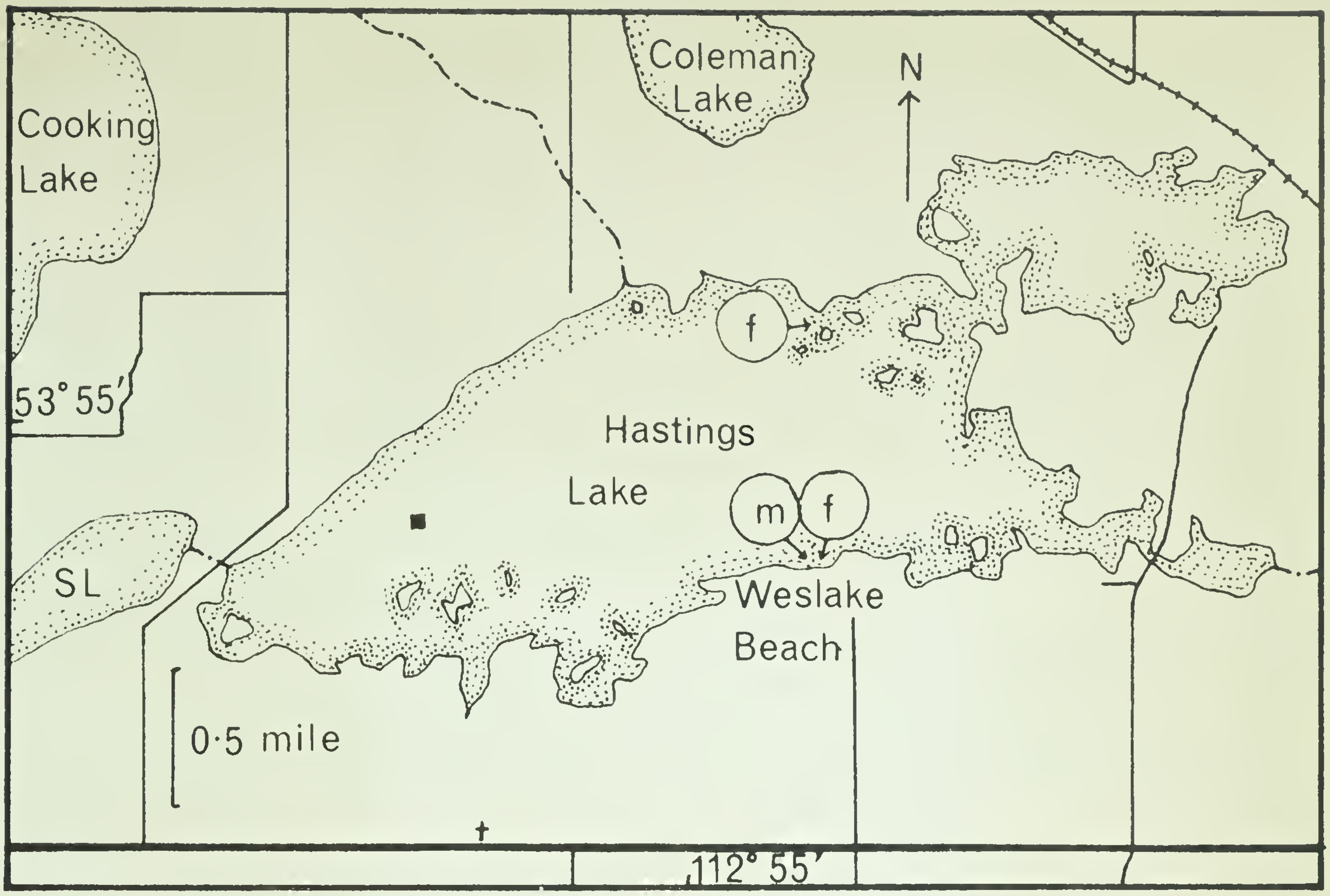


Fig. 14. Distribution of the species in Hastings Lake.

(f) -- Region where P. fungosa was found

(m) -- Region where C. mucedo was found

++++ -- Canadian National Railway

—— -- Gravel road

▬▬ -- Highway 14

+ -- Historical site

-.-.-' -- Intermittent stream

-- Lake

■ -- Dredging site

were obtained at a distance of about 30 meters from the northern shore (Fig. 14).

In 1962 the beach was again extensively cleaned and treated with copper sulphate. Numerous dead colonies of P. fungosa lay on the beach; their floatoblasts could be collected. After these dredgings and chemical treatments, Weslake Beach became a clean resort, albeit unsuitable for the growth of ectoprocts.

A dredge was carried out off the northwesten shore (Fig. 14) on June 13, 1962. Only a few chironomid larvae were found.

Compared with Amisk Creek, Hastings Lake was comparatively cool and the fluctuation of pH was not so great. The physicochemical data of the lake and a chemical analysis of water sample are given in Table XI and XII respectively.

c. Lac Ste. Anne

In 1958 R. Carefoot collected a large colony of P. fungosa on a reed stem near Alberta Beach, a resort area at the southeastern corner of the lake. Its mature form, however, was not reencountered. Only its floatoblasts could be obtained in subsequent seasons. On May 15, 1962 the water was relatively cool (12.0°C.), alkaline (pH = 9.5), and well oxygenated.

4. Plumatellid Floatoblasts

Table XI. Physicochemical data of water from Hastings Lake.

Date	Locality	Temperature (°C.)	pH	Dissolved oxygen (% sat'n at sea level)
1961				
Aug. 31.	Weslake Beach	18.0	7.6	73
Sept. 4.	Weslake Beach	18.0	8.6	145
12.	Weslake Beach	14.0	8.7	130
16.	Weslake Beach	16.5	8.6	141
24.	Weslake Beach	12.0	9.1	130
Oct. 7.	Weslake Beach	9.0	8.0	112
10.	Weslake Beach	8.5	8.5	118
1962				
May 10.	Weslake Beach	10.5	9.0	150
21.	Weslake Beach	16.5	9.0	116
June 2.	Weslake Beach	16.5	8.5	54
13.	Northwestern Shore	18.0	9.0	142

Table XII. Chemical analysis of water sample from Weslake Beach on Hastings Lake. May 21, 1962.

	Parts per million
Total solids	740
Ignition loss	220
Hardness	275
Sulphates	212
Chlorides	4
Alkalinity	245
Nature of alkalinity	$Ca(HCO_3)_2$, $Mg(HCO_3)_2$.
Nitrites	0
Nitrates	0
Iron	1

Since floatoblasts could be seen more readily than the matured colonies, they were collected from many places (Table II) where the adults were not found. Since correct identification calls for the examination of colonies as well as floatoblasts, and since floatoblasts belonging to the genus *Plumatella* resemble one another closely, floatoblasts *per se* gave limited information only. Hence, they were tentatively listed under the genus *Plumatella*. In two instances, however, they could be resolved to the species level. On the basis of previous collections of colonies of *P. fungosa* from Lac Ste. Anne and Hastings Lake, it was inferred that the floatoblasts collected from these two areas probably belonged to the same species.

Environmental data were not taken in all the areas where only floatoblasts were found. Those pertaining to Hastings and Wabamun Lakes as well as Lac Ste. Anne have been presented elsewhere. Those pertaining to Cooking are given in Tables XIV and XV.

5. *Cristatella mucedo* Cuvier 1798

This species was collected from three localities where at least one other species of phylactolaemate has been found. The environmental data of these habitats have been presented previously and will not be reproduced in this section.

Table XIII. Physicochemical data of water from Cooking Lake.

Date	Locality	Temperature (°C.)	pH	Dissolved oxygen (% sat'n at sea level)
1961				
Sept. 4.	Lake View	14.0	8.7	134
12.	Lake View	16.0	8.5	140
1962				
Apr. 29.	Cooking Lake	4.0	8.5	68
May 10.	Cooking Lake	11.0	9.5	166
21.	Cooking Lake	14.5	9.5	141
June 2.	Cooking Lake	20.5	9.0	85

Table XIV. Chemical analysis of water from Cooking Lake. May 21, 1962.

	Parts per million
Total solids	1,246
Ignition loss	394
Hardness	260
Sulphates	323
Chlorides	8
Alkalinity	375
Nature of alkalinity	Na_2HCO_3, $Ca(HCO_3)_2$ and $Mg(HCO_3)_2$.
Nitrites	0
Nitrates	0
Iron	0.2

a. Amisk Creek

C. mucedo was found in Amisk Creek in 1960 shortly after the discovery of *Plumatella fungosa* in this area. The two species occurred near but never in actual contact with each other beneath the railway trestle in 1960 and 1961 (Fig. 10). When *C. mucedo* was first obtained on stones and *Ceratophyllum* at a depth of half a meter on August 3, 1960, the colonies were already growing luxuriantly. Shortly afterwards, they were also found abundantly on *Ceratophyllum*, south of the picnic ground (Fig. 10 and Plate X). By September spinoblasts were plentiful. The colonies were still growing on November 29, when a thin ice cover was beginning to form. No attempt was made to examine their condition after the formation of a complete ice cover. It is probable that as in Wabamun Lake, the ice would extend to the shallow bottom during the winter months and that the ectoprocts would become frozen in.

The colonies were again growing luxuriantly on June 2, in the following season. By June 20, they appeared senile with spinoblasts. Two weeks later, their numbers decreased considerably. By July 14, their vitality was fatally affected following a sudden drop in the water level of about 0.6 meter. They were not found again in 1962.

b. Hastings Lake

Several colonies of *C. mucedo* were collected in 1960 and 1961 on *Ceratophyllum* at a depth of about 0.7 meter at

Plate X. Amisk Creek, south of the picnic ground where C. mucedo was found (see Fig. 10). September, 1961.

the western end of Weslake Beach, Hastings Lake (Fig. 14), where _P. fungosa_ was also found. _C. mucedo_ was not found in 1962.

c. Wabamun Lake

No sign of _C. mucedo_ could be detected in Wabamun Lake when _Fredericella sultana_ was being studied. However, several small colonies of _C. mucedo_, senile with spinoblasts, were obtained at a depth of half a meter on _Ceratophyllum_ in the outlet canal of the Calgary Power Plant (Fig. 7) in September, 1961 by P. Paetkau.

C. Some Localities Where the Species Were Not Found

Table XV includes some of the localities which I have visited without detecting any sign that would indicate the presence of ectoprocts. Inadequate collecting might account for their apparent absence in those places where only one trip was made. Otherwise, the absence of ectoprocts should be assumed for the season specified.

IV. DISCUSSION

Investigations were usually confined to the vegetation zone fringing the shoreline. With the use of the rake most of this area could be sampled, even in parts too

Table XV. Record of collecting trips in which ectoprocts were not found. The dates given refer to the first visit if more than one visit was made. Dates of subsequent visits are not given. An asterisk indicates that only one collecting trip was made.

Date	Locality
1960	
May 20.	Three sloughs eight Km. east of Ellerslie(1).
20.	A slough five Km. east of Ellerslie.
June 4.	A slough 27 Km. west of Edmonton.*
7.	A slough 24 Km. southeast of Edmonton.*
18.	A slough east of Bretona.*
23.	A slough north of Winterburn.*
27.	Cawes Lake.
30.	Lake Eden.
July 7.	Allen Beach.
Aug. 27.	Egg Creek, three Km. west of Namao.
27.	Sturgeon River in St. Albert.
27.	Qui Barre River, three Km. east of Villeneuve.*
1961	
June 19.	Three sloughs eight Km. east of Ellerslie(1).
Aug. 15.	Sturgeon River at Gibbon.*
15.	Redwater River.*
15.	A slough near Vilna.*
19.	A slough 48 Km. from Edmonton on Highway 14.

(cont'd)

Table XV (cont'd)

Date	Locality
Aug. 21.	Magnolic Bridge.*
21.	Sturgeon Creek at Highway 16 West.*
21.	Pembina River at Highway 16 West.*
22.	Lake Edith.*
22.	Lake Annette.*
22.	Medicine Lake.*
22.	Pyramid Lake.*
23.	Leach Lake.*
24.	Jonas Creek.*
25.	Vermillion Lake.*
1962	
Apr. 29.	Cooking Lake(2).
May 26.	Ministik Lake.*
June 12.	Three sloughs eight Km. east of Ellerslie(1).
July 17.	A slough near Sherwood Park.*
20.	Frank Lake.*
29.	Sylvan Lake.*
29.	Blindman River near Bentley.*
29.	McLaurin Beach, Gull Lake.*

(1) Plumatella repens was collected only once in 1959.

(2) Plumatellid floatoblasts were collected once in 1961.

deep to wade. The deeper water beyond the fringing vegetation zone was seldom sampled, and this might appear to constitute a weakness of the method. Where ectoprocts are present in a body of water, however, they are usually abundant near the shoreline and failure to discover them here is a good indication that they are not present (Brown, 1933).

Despite close attention given to searching, it was found impossible to cover the entire habitat with the same thoroughness. The hit-or-miss tactic became the rule. To offset this, a preliminary step was always employed to check for any sign that would indicate the presence of these animals, for instance, the presence of floatoblasts, or skeletons of deceased colonies. By so doing the presence of the phylactolaemates was frequently disclosed even though their living forms could not be obtained (See Plumatellid Floatoblasts in Table II).

Because this study covers many localities (13 in all, Table II) that fostered the species, there was insufficient time to permit examination of each locality with tha same thoroughness. Amisk Creek and Wabamun Lake, especially the former, were deliberately given more attention than the rest, not only because they were easily accessible but also because they held the two largest populations, namely, _P_. _fungosa_ and _F_. _sultana_ respectively. The motile _C_. _mucedo_ was also found in their proximity.

A. An Ecological Review of the Four Species

1. Fredericella sultana

This species is generally found in alkaline running water that is not very deep (Brien, 1960). Its habitation, however, is more variable than that of the other phylactolaemates except possibly Plumatella. It has been obtained from shallow regions as well as from deep regions (down to 170 meters) in large lakes, from well-illuminated localities as well as from dark localities (as in water pipes), from quietly flowing water as well as running water, from acid lakes in Utah and Wyoming (pH 5.3 to 5.8) as well as from alkaline lakes (Hyman, 1959). It was no surprise, therefore, that this species was collected from two different habitats in this province. As a member of the bottom fauna, it was dredged from various depths (down to 21 meters) in Amethyst Lake (Rawson, 1953a); as a fouling organism, it was obtained from the shallow submerged stumps beneath the long trestle in Wabamun Lake (Fig. 7 and Plate I). It was also found on vegetation near the surface along the outlet canal of the Calgary Power Plant. This species has penetrated into northern latitudes (Greenland, 69° N., see Table XVII) further than any other phylactolaemates (Hyman, 1959) and thus can be assumed to have a better tolerance for low temperatures. It is not surprising, therefore, that it continued to grow profusely toward the latter part of the season in Wabamun Lake until it was probably frozen in by the formation of an ice cover. Attempts to find it in the lake bottom were

fruitless, but its presence should not be absolutely precluded. It would be of interest to compare the deep and the shallow-water forms for possible physiological differences. Like *Paludicella* and *Lophopus*, *Fredericella* may overwinter in depths (Pennak, 1953).

Prosser and Brown (1961) reported a variety of effects of dietary lipids on temperature tolerance in poikilotherms. It would be of interest to know if there are more lipids in the diet of the circumpolar species such as *F. sultana* and *C. mucedo* than in the diet of the other phylactolaemates.

All the particles suspended in water that are not too large or too active are eaten by ectoprocts. Because the plankton identified in the present study consists chiefly of the larger and the more conspicuous forms, their value as food for ectoprocts is thus uncertain. It is generally believed that the ectoprocts feed on plankton, but some plankton may be passed out in the fecal pellets alive. Mackie (personal communication) suggests that the microorganisms may be important in their diet.

The occurrence of phylactolaemates and sponges in close proximity has often been recorded. Their relationship has never been probed, however. Two examples of this are furnished in Alberta: *F. sultana* and *Meyenia* sp. in Wabamun Lake, and *P. fungosa* and *Spongilla* sp. in Amisk Creek. The intimacy of their association is related to the morphology

(Material deleted after submission of thesis)

of the ectoprocts. The colonies of *F*. *sultana*, being branching, antler-like, partly creeping and partly erect (Fig. 1C), could infiltrate themselves into the colonies of *Meyenia*. The colonies of *P*. *fungosa*, being compact and massive (Fig. 3C), could not do so. Suffice it to say that the environmental conditions were suitable for both groups and that they were competing for the same substrata. It is possible that such an association helps to create stronger food currents that are beneficial for their feeding.

Generally, not all the species of Ectoprocta known to occur in a region will be found in any one habitat but as many as three or four species may grow in close proximity (Brown, 1933). There is in Alberta one example where three species were found in a locality. *F*. *sultana*, *C*. *mucedo* and floatoblasts of *Plumatella* were collected from Wabamun Lake. There is also an example where two species occurred in close proximity. Both *P*. *fungosa* and *C*. *mucedo* occurred in Amisk Creek and Hastings Lake. These findings agree with Pennak (1953) who mentions that *Fredericella*, *Plumatella*, *Pectinatella* and *Cristatella* are sometimes found in the same body of water at the same time.

Like *P*. *fungosa* and *C*. *mucedo* in Amisk Creek, *F*. *sultana*, when found, had already grown profusely. Failure to observe it earlier may be attributed to its slow initial growth. Hyman (1959) reports that colony growth from a statoblast is slow at first, often one to six weeks may

elapse before the second polypide emerges. Later ones are produced at intervals of one to eight days and as the colony enlarges, several polypides may arise daily under favorable conditions.

Hyman (1959) suggests that the composition of water is probably important for the distribution of Ectoprocta but little specific information is available. Brown (1933) collected some ectoprocts from water with a dissolved oxygen content ranging from 6.3 to 7.4 ml. per liter. Pennak (1953) reports that some ectoprocts are found, albeit sparingly, in water where the dissolved oxygen content falls below 30 per cent. The water in the Edmonton area has a much higher percentage saturation (from 71 per cent to oversaturation). According to Allee _et al_. (1959) most of the freshwater bodies have a range of pH from 6.5 to 8.5. The range in the Edmonton area is slightly higher (7.0 to 10.0). Rogick (1935) collected many species of ectoprocts from Lake Erie in Ontario which had pH values of 7.2 to 8.0. The figures fall within the range of the pH values in the Albertan water.

A comparison of the chemical analyses of samples taken from various places in Alberta (Tables V, VII, XII and XIV) indicates that _F. sultana_ requires less total solids, organic matters, and sulphate ions than _P. fungosa_ and _C. mucedo_. On the other hand, it prefers harder water than these two species. They require about the same

amount of alkalinity. The presence of calcium and magnesium in all the water samples appear to indicate that these ions are required by the phylactolaemates. Calcium, in particular, has frequently been related to the distribution of some species of freshwater animals (Macan, 1961).

Wabamun Lake appears to be a favorable locality for further researches on the phylactolaemates.

2. *Plumatella repens*

P. repens is "cosmopolitan in lakes, ponds, and streams everywhere" (Hyman, 1959). It was found in two strikingly similar sloughs in Alberta. Sloughs are numerous here, and consequently, not all of them could be searched thoroughly. Because of the small size of the colonies and their obscure habitation (as delicate traceries on some submerged vegetation), the species was considerably more difficult to find than the other three forms. This may account for its spotty distribution as well as its apparent absence from lakes and streams in this province.

The slough near Ellerslie remains puzzling as *P. repens* was found here once in 1959 but not subsequently. Presumably, the environment has since became unsuitable for this species. However, the pH, an index for the general condition of an environment, did not change much (about pH 8.0) over the four-year study period since its discovery in 1959.

According to Rawson and Moore (1944) this species was collected in Waskesiu Lake in Saskatchewan. The lake was fresh (total solids = 171 p.p.m.), clear (Secchi disk reading = 5.5 meters), relatively cool (18.8°C.) in July, well-oxygenated (103 percentage saturation) and alkaline (pH = 8.1). Compared to this lake, the slough near Frank Lake was also alkaline and well-oxygenated.

3. *Plumatella fungosa*

P. fungosa was found in three seasons in Amisk Creek. In 1960 when the study began, it flourished in the second half of the season while in 1961 and 1962 it grew only in the first half. The 1960 population was probably a product of both asexual ("statoblast-colonies" and budding, Oda, 1959) and sexual ("embryo-colonies") reproduction. It achieved greater abundance than did the populations in the other seasons. It died a natural death with the onset of winter. The 1961 and 1962 populations were less fortunate as abrupt changes of water levels in the summers affected them fatally. Only one

short-lived colony was observed in the larvae trap after the disaster in 1961. Since the water level in the creek was dependent on the run-offs, the weather thus indirectly affected the well-being of the ectoprocts.

Because of their growth pattern, the massive colonies of _P. fungosa_ form an excellent substrate for a variety of organisms. Most of these do little harm to their hosts. When chironomid larvae and naid oligochaetes are present in great numbers, however, they often cause serious damage to the colonies by devouring numerous polypides and statoblasts. As fish feed on chironomid larvae, ectoprocts thus become an indirect source of nourishment for fish (Marcus, 1926). Filamentous algae too, can entangle the zooids in such a way that the lophophores cannot protrude for feeding and consequently starve to death.

Minnows in schools frequently browsed near the ectoprocts in Amisk Creek. It was not certain if they fed on the colonies. Osburn (1921) reported that the statoblasts of _Plumatella_ and _Pectinatella_ were found among the stomach contents of the young of the large-mouth black bass (_Micropterus salmoides_), the crappie (_Pomoxis annularis_), the blue-gill sunfish (_Lepomis pallidus_), and the gizzard shad (_Dorosoma cepedianum_)in Ohio. Two species of phylactolaemates, _Lophopodella carteri_ and _Pectinatella gelatinosa_, have been reported to be toxic to some fish (Oda, 1958) but they are not present in Alberta. Waterfowl have been reported to feed on ectoprocts, but I have not witnessed this myself. In an

analysis of the food habits of migratory ducks in Illinois in 1939 to 1941, Anderson (1959) found that ectoprocts, when present, appeared most often as traces in the gizzards. They were found in 136 out of 4505 gizzards (three per cent) examined. Statoblasts of *Plumatella* and *Pectinatella*, probably eaten along with other food, were found in the gizzards on nine species of ducks, namely, mallards (*Anas platyrhynchos*), pintails (*A. acuta*), green-winged teal (*A. carolinensis*), blue-winged teal (*A. discors*), baldpates (*Mereca americana*), shovelers (*Spatula clypeata*), redheads (*Aythya americana*), ring-necked ducks (*A. collaris*) and greater scaups (*A. affinis*). It is probable that those ectoprocts growing in exposed localities such as the submerged stumps beneath the trestles are prone to predation by fish and those growing near the surface and the shorelines are vulnerable to birds. Such predation has not been reported to be harmful to the ectoproct population as a whole.

It is of interest to note that the chemical contents of the water in Amisk Creek decreased during the three-year study. Table VII shows that the ignition loss decreased from 130 p.p.m. in September of 1960 to 32 p.p.m. in April of 1962, and the alkalinity decreased from 195 p.p.m. to 100 p.p.m. during the same time. In view of Rawson's (1951) report, it is probable that the increased outflow and inflow of water in 1961 and 1962 brought about the decrease in the quantities of total solids which is a good index for the amount of free flows and edaphic situation in a body of water. Compared with

the rough estimate (15 to 300 p.p.m.) given by Welch (1952), the amount of total solids in Amisk Creek (234 to 412 p.p.m.) is not high but those in Hastings (740 p.p.m.) and Cooking (1,246 p.p.m.) Lakes are. By the criterion proposed by Hesse et al (1935, cited in Rawson, 1951), the last two lakes are saline lakes. According to Lister (personal communication), these lakes have been slowly drying up since the thirties.

Like C. mucedo, P. fungosa requires more total solids (over 200 p.p.m.), organic matter and sulphate ions than F. sultana. Both of them prefer softer water, and are indifferent to the presence of small amount of nitrates, nitrites and iron. The presence of P. fungosa and C. mucedo in Amisk Creek and Hastings Lake show that they can tolerate a considerable range of salinity. Indeed, a species of Plumatella was collected from Echo Lake, a saline lake with a total solids of 1,285 p.p.m., in Saskatchewan in 1939 (Rawson and Moore, 1944). Being 17 meters deep, the lake was comparatively cool (19.7°C. in August), not very clear (Secchi disk reading = three meters), well oxygenated (100 per cent), and alkaline (pH = 8.7).

Plumatella, together with statoblasts of Pectinatella, was also found in several freshwater lakes, including Waskesiu Lake, in Prince Albert Park in Saskatchewan (Rawson and Moore, 1944). Like Echo Lake, Waskesiu Lake was also cool (18.8°C. in July), well oxygenated (103 per cent) and alkaline (pH = 8.1); but unlike Echo Lake, it was much deeper (25 meters) and definitely freshwater (total mineral

content = 171 p.p.m.).

From submerged logs in Lake Simcoe in Ontario, Rawson (1930) collected species of Plumatella which formed a scattered covering on the rotting wood just below the water level. Being 45 meters deep at an altitude of 220 meters, the lake was cool (0.8° to 18.2°C. from May to September), clear (Secchi disk reading = six meters) and alkaline (pH = 8.1). Here, statoblasts of Cristatella were also found.

Plumatellid statoblasts were also obtained from Beaver Lake (also known as Swalwell Lake) in British Columbia at an altitude of 1,400 meters (Rawson, 1939). Being 25 meters deep, the lake was cold (13.4° to 15.6°C. in July and August), fairly well oxygenated (83 to 87 per cent) and almost neutral (pH 6.9 to 7.3). Copepods, rotifers and midge larvae were abundant here.

It is thus apparent that Plumatella species live in well oxygenated water, the salinity and alkaline pH of which may fluctuate considerably.

4. Cristatella mucedo

Like Lophopus, Lophopodella and Pectinatella, Cristatella has also acquired a capacity for slight locomotion on the substratum (Rogick, 1959). The fact that it can glide on the slender leaves of Myriophyllum is a genuine feat. The mechanism for such movement is obscure. It has been suggested that ciliary action on the tentacles, the musculature

of the body wall, and perhaps the action of the retractor muscles are involved (Pennak, 1953). In view of the histological studies of Brien (1953), Hyman (1959) suggests that locomotion could be accomplished by alternate contractions and expansions of the circular and longitudinal muscles of the sole. Like Lophopodella and Pectinatella, some colonies of Cristatella occasionally undergo fission (also called "autonomic regeneration" by Buddenbrock, 1924) and move apart (Fig. 4D). My observation confirms that of Wesenberg-Lund (1897, cited in Hyman, 1959) who reported that fission was more frequent when the colonies were in the open air than in the water. It must, therefore, be a device for increasing the probability for survival. Marcus (1926) proposed that an accidental split in the cystid was necessary to initiate fission.

Gelatinous ectoprocts are somewhat limited to still waters (Hyman, 1959). C. mucedo, a gelatinous form, may also dwell in the quiet parts along a flowing stream. While there was only slow current in Amisk Creek, there was considerable flow in the outlet canal in Wabamun Lake, and both of these regions fostered the species among the fringing vegetation zone where the amount of water movement was not so great. Nymphaea, a yellow lily, is generally considered as a favored substratum for C. mucedo (Hyman, 1959), but such an association was not observed in Alberta.

According to Rawson (1939), C. mucedo was collected from Beaver Lake and Woods Lake in British Columbia. While

the conditions pertaining to the former have been given, those pertaining to the latter are here included. Being 32 meters deep, Woods Lake was comparatively cool (18.5°C. in August), fairly well oxygenated (86 per cent) and alkaline (pH = 8.4). The lake also fostered numerous blue-green alga (Aphanizomenon), copepods, rotifers, oligochaetes and midge larvae.

In Japan, Oda (1954) observed some double polypide-monsters in Cristatella with twin lophophores and twin polypides enclosed in common tentacular sheaths. Such examples have not been obtained in Alberta.

B. Significance of the Present Findings in terms of the Canadian and Global Distribution

Table XVI presents the distribution of the four species in Canada. C. mucedo, being a circumpolar form, was found in most of these lakes. The two other genera were also well represented. These three genera were all present in Great Slave Lake in the Northwest Territories which is located at about 62° N. latitude. It is of interest to note that with the exceptions of White and Rogick, the other discoverers were limnologists whose main interests were not in these fauna.

Two additional species are known to occur in Canada. They are Paludicella articulata (Ehrenberg) 1831 (Class Gymnolaemata) which have been collected from Lake Erie in

Table XVI. Distribution of the four species in Canada, compiled from various sources.

Region	FS	PS	PR	PF	CM	Reference
Canada	X		X	X	X	White, 1915
Lake Simcoe, Ont.		X			S	Rawson, 1930
Lake Erie, Ont.	X		X		X	Rogick, 1935
Echo Lake, Sask.		X				Rawson & Moore, 1944
Weskesiu Lake, Sask.		S	X			Rawson & Moore, 1944
Amethyst Lake, Alta.	X					Rawson, 1953a
Beaver Lake, B. C.		S			X	Rawson, 1939
Woods Lake, B. C.					X	Rawson, 1939
Great Slave Lake, N. W. T.	X		X		X	Rawson, 1953b

CM -- C. mucedo

FS -- F. sultana

PF -- P. fungosa

PR -- P. repens

PS -- Plumatella sp.

X -- matured colonies were present

S -- Statoblasts only were present

Ontario (Rogick, 1935) and Great Slave Lake (Rawson, 1953b), and *Pectinatella magnifica* Leidy 1851 (Class Phylactolaemata) that have been collected from Lake Erie (Rogick, 1935), Dundas Marsh in Hamilton, Ontario (Judd, 1950) and Waskesiu Lake in Prince Albert Park, Saskatchewan (Rawson and Moore, 1944).

Table XVII presents the distribution of the four species in the world. They all occur in Britain, Canada, France, Germany, Japan and the United States of America within the north temperate zone. They are also found in Finland, Sweden and the eastern territory of the Union of Soviet Socialist Republics within the circumpolar region. The present findings accord with the general pattern of the phylactolaemate distribution.

Table XVII. Distribution of the four species in the world, compiled from various sources, chiefly Hyman (1959).

Region	FR	PR	PF	CM	Reference
NORTHERN LIMITS					
Greenland (69° N.)	X				Wesenberg-Lund, 1907
Kola Peninsula (66° N.)				X	Abricossoff, 1933
Spitzbergen		S			Richard, 1897
Nowaya Zemlya		S			Abricossoff, 1933
Finland	X	X	X	X	Levander, 1908
Sweden	X	X	X	X	Borg, 1941
Iceland	X			S	Helding, 1938
Kodiak Is., Alaska	X				Robertson, 1900
Far Eastern Territory of U.S.S.R.	X	X	X	X	Abricossoff, 1959
SOUTHERN LIMITS					
Tierra del Fuego	X				Calvert, 1904
New Zealand	X				Dendy, 1906
ALPINE & SUBALPINE LAKES					
Switzerland	X				Forel, 1884
Northern Italy	X				Du Plessis-Gouret, 1884
Pyrenees	X	X		X	Despax, 1926
Caucasus		X			Richard, 1896
Brazil	X				Eve. Marcus, 1946
Uintah Mountains, Utah	X				Tanner, 1932
Lake Lucerne	X				Zschokke, 1906

(cont'd)

Table XVII (cont'd)

Region	FS	PR	PF	CM	Reference
NORTH TEMPERATURE ZONE					
Britain	X	X	X	X	Allman, 1856
Canada	X	X	X	X	White, 1915
France	X	X	X	X	Prenant & Bobin,1956
Germany	X	X	X	X	Borg, 1930
U. S. A.	X	X	X	X	Rogick, 1934-50
ORIENTAL					
China	X	X	X		Abricossoff, 1959
India	X				Annandale, 1911
Indonesia		X			Vorstman, 1928
Japan	X	X	X*	X	Toriumi, 1951-56
Korea	X	X	X		Abricossoff, 1959
OTHER COUNTRIES					
Africa	X	X			Borg, 1936
Brazil	X	X			Marcus, 1941-42

CM -- C. mucedo S -- Only statoblast were present

FS -- F. sultana X -- Mature colonies were present

PF -- P. fungosa * -- Toriumi considers P. fungosa as a variant of P. repens

PR -- P. repens

V. SUMMARY

1. The Ectoprocta are small, sessile, aquatic and colonial coelomates. About 50 species are known to occur in freshwater. This is the first report on their habitats and distribution in central Alberta.

2. During the study period, from May, 1960 to July, 1962, four species were found. They are:

Fredericella sultana (Blumenbach) 1779,
Plumatella repens (Linnaeus) 1758,
Plumatella fungosa (Pallas) 1768 and
Cristatella mucedo Cuvier 1796.

3. Of these species, the first three have been collected previously: *F. sultana* was collected from Amethyst Lake in 1946, *P. repens* from a slough near Ellerslie in 1959 and *P. fungosa* from Lac Ste. Anne in 1958. Only the occurrence of *F. sultana* in Amethyst Lake was published, however (Rawson, 1953a). Because of its great distance from Edmonton, the lake was not reexamined. For reason unknown, *P. repens* was not rediscovered in the slough near Ellerslie. In Lac Ste. Anne only plumatellid floatoblasts were found.

4. This study furnishes the following new information on the occurrence of Ectoprocta in Alberta: *F. sultana* was found in Wabamun Lake in 1961 and 1962; *P. repens* in a slough near Frank Lake in 1962; *P. fungosa* in Amisk

Creek and Hastings Lake in 1960 to 1962; C. mucedo in Amisk Creek and Hastings Lake in 1960 and 1961 and in Wabamun Lake in 1962; and unidentified plumatellid floatoblasts in Camrose Creek, Lac Ste. Anne, Astotin, Baptiste, Chickakoo, Chip, Cooking, Isle and Wabamun Lakes. These localities, including Amethyst Lake, lie within the confines of 50.5° N. to 55.0° N. latitudes and 112.5° W. to 118.5° W. longitudes at 680 to 1,960 meters above sea level.

5. Amisk Creek and Wabamun Lake, especially the former, were deliberately given more attention than the rest not only because they are easily accessible but also because they held large populations of F. sultana, P. fungosa and C. mucedo.

6. The field data for the four species presented in the following table (Table XVIII) are discussed in the light of our present knowledge on these fauna.

Table XVIII. Summary of the field data for the four species. The mean values are included in parentheses.

	F. sultana	*P. repens*	*P. fungosa*	*C. mucedo*
Types of habitat	Lakes	Sloughs	Slow streams and lakes	Slow streams and lakes
Depth (m.)	0.2 - 21.0	0.3 - 0.7	0.2 - 1.0	0.3 - 1.0
Substrata	Lake bottom, submerged stumps, narrow-leaved *Potamogeton*	*Myriophyllum*, reeds	Submerged stumps, tree branches, broad-leaved *Potamogeton*	*Ceratophyllum*, stone, submerged metal objects
Highest temp. (°C.) recorded	23.0	24.0	26.0	26.0
pH	7.5 -9.5 (8.1)	7.5	7.0 - 10.0 (8.2)	7.5 - 9.3 (8.0)
Dissolved oxygen (% sat'n at sea level)	86 - 131 (108)	Over-saturated	71 to over-saturated (115)	76 to over-saturated (118)
Relative light penetration to substratum	++++ to +	++	+++ to +	+++
Relative degrees of current	++++	+	++	++
Total solids (p.p.m.)	194	--	234 - 740 (399)	194 - 740 (370)
Ignition loss (p.p.m.)	12	--	32 - 220 (111)	92 - 130 (108)
Hardness (p.p.m.)	150	--	80 - 275 (124)	80 - 275 (120)
Alkalinity (p.p.m.)	200	--	100 - 245 (165)	100 - 245 (136)

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